Introduction to Firearms

SONORAN DESERT INSTITUTE

SCHOOL OF FIREARMS TECHNOLOGY

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Introduction

Welcome to the world of gunsmithing. It is a fascinating world with many opportunities for individuals who want to make a good future for themselves. Gunsmithing is also suited to those firearm enthusiasts who want to keep their own firearms in perfect operating condition and have features on their guns that are unobtainable from the manufacturers. In either case, you have taken an important first step by deciding to take this course in gunsmithing.

Consider us at Sonoran Desert Institute as your partners in climbing the ladder to the future you want. We want to help you achieve success as you learn everything about firearms — from troubleshooting and repairs to

building one-of-a-kind custom rifles. We will be at your side every step of the way, helping you to learn and start your new career as a gunsmith.

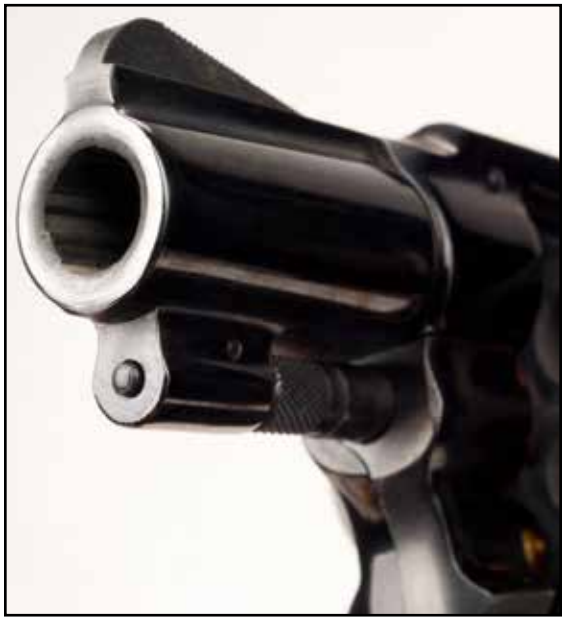
But even if you do not want to go into gunsmithing on a full-time basis, the course will still do many good things for you. What you learn from the course will enable you to troubleshoot and repair almost any firearm–no more waiting several months to get your own firearms repaired by a professional. With Sonoran Desert Institute training and the accompanying tools, you will be able to do most jobs yourself. Once you get your Federal Firearms License, you will also be able to buy guns and ammunition at wholesale prices, work on customer firearms, or provide special order services, which can mean a significant savings to you.

Over 37 million hunting licenses are issued each year in the United States, with an estimated 310 million firearms in civilian households. There are also thousands more being manufactured or imported each year. All of these firearms will eventually need repairs. This is where you come in. With the knowledge that you gain from this course, and the practical shop experience we recommend for you, you should be able to cure many of these "sick" guns and put them back into service, all the while getting paid for your time.

Furthermore, you can learn the ins and outs of all types of firearm actions: single-shots, bolt-actions, lever-actions, slide-actions, and even semi-automatic weapons. This knowledge will broaden your opportunities for profitable employment with existing gun shops or firearm manufacturers. Really good gunsmiths are in short supply in the United States.

The beauty of the Sonoran Desert Institute gunsmithing program is that you can start out by handling minor gun repairs, mounting telescope sights, boresighting rifles and installing rifle slings and such at night or on weekends while still keeping your regular job. Then later, as business builds, you can go to work in a regular gun shop or open your own business. Either way, the training that we provide will help you every step of the way.

Your Sonoran Desert Institute training is designed to make you a top-notch service technician. You will learn not only how firearms work and how they are constructed and operate, but also how to fix the trouble when something goes wrong.



Safety

GUN SAFETY

Firearms and shooting can be inherently dangerous by nature, but strictly adhering to a set of rules will ensure that you and everyone around you are safe. Firearms should not be feared, but they should definitely be respected. Just like with other dangerous things in our lives, we learn how to safely handle and manipulate them. Firearms are no different — you must learn and strictly follow each and every safety rule at all times. Becoming lax with safety is a sure way for someone to get hurt or worse. Following these simple rules will ensure that even if an accident were to occur, everyone will be safe.

1. Treat every firearm as if it were loaded.

There is an average of over 600 unintentional firearm deaths per year, with about 15 percent of those being children between the ages of 3 and 16. This is all because someone assumed a firearm was empty or safe or was not taught otherwise. There is seldom a way of just seeing that a firearm is safe — you must physically and visually make sure that it is. If you are unfamiliar with the way a certain firearm functions, ask someone who is, find a factory manual, or use the internet, but make sure you understand how to safely use it. Teach children never to touch a gun unless there is adult supervision, and leave it alone and find an adult if one is not already present. The same rules apply when you are training or teaching safety with "Blue" or training guns. Teaching children and beginners to treat toys (BB, Nerf, or Airsoft) like real loaded firearms will cement this rule into them so when they are handling real firearms, they will do so in a safe manner.

2. Never point a firearm at anything you do not intend to destroy.

This point cannot be stressed enough: DO NOT under any circumstance point a firearm at another person, living thing, or property. The only exceptions are legal hunting and when you are in absolute fear that your life or the life of another is going to be taken. Even if you know the firearm is safe and empty, it is still offensive and punishable by law to point a firearm at another person. Safeties fail and accidents happen, so you do not want to point a gun at something or someone you do not wish to destroy. As a gunsmith, in the course of your work you may break this rule as you are working on a firearm. We will add an additional rule on protecting yourself as we lay out the rest of the rules.

3. Keep your finger off the trigger until you are ready to shoot.

There are situations where you will move around while carrying your firearm, such as walking through the woods while you stalk your game, running around a course during some type of competition, or even clearing rooms in your house in the dark when you hear a window break or a door bust open. No matter what you are doing, you must remember to ALWAYS keep your finger off the trigger. People trip and fall, bump into things, get scared and also excited. These are all situations that can result in an unintentional discharge. In fact, your finger should be OUTSIDE the trigger guard.

4. Always be sure of your target and what is behind it.

This rule can be broken down into two different parts: the actual target and the surrounding area. Targets can be made of many different materials and configurations, all of which can react differently from a bullet impact. While hunting, it is important to be sure you are shooting the right

animal; you don't want to shoot a doe when your tag is for a buck. It is very important to properly identify your target, and if you are unsure of it, you should not point your gun to gamble with your freedom or a life.

It is also important to remember that there isn't much that can stop a bullet. Animals and people, cars, buildings or anything else outside of appropriate backstops, some armors, and bullets designed with limited penetration or fragmentation will not stop a bullet. Be sure that those targets that you set up have a backstop that is going to stop the bullets and all of their pieces. Be sure the elk you are shooting at doesn't have another hunter on the opposite side trying to take his own shot. In any of these scenarios it is important not to get anxious or excited or even scared and unintentionally shoot something you didn't mean to. From punching a hole through paper or wood and continuing through until it runs out of energy, to fragmenting on rocks or through an animal and even ricocheting off water, you are responsible for every piece of that bullet and where it impacts.

Another aspect of this rule has arisen in recent times with the popularity of the silhouette and steel target. These targets can be extremely fun and rewarding to shoot with their instant

Figure 1: Keep your finger outside of the trigger guard, up along the frame or cylinder.

feedback, but they pose a real danger if not set up properly. A majority of these targets require that you are a certain distance away from the target or the target is set at an angle to deflect the ricocheting projectiles or fragments. Follow all of the manufacturer's rules when shooting steel targets to ensure your safety and the safety of others around you.

5. Know how to safely operate your firearm and how all of its safeties work.

It is important to know how to safely handle and operate EVERY firearm that you own or use. If you buy new or used, obtain a copy of the factory owner's manual. If you can't find a manual, ask a dealer or a gunsmith or use the internet. There are many different types, actions, calibers, configurations, and conversions out there and too many ways to do something wrong. You don't want to face an attacker and not know how to deactivate your safety and instead release your magazine, or forget you have to manually cycle a bolt-action for a follow-up shot on an animal you missed with your first. Negligent or accidental discharges are not the fault of the gun; the operator is at fault 99.9 percent of the time whether it be from inexperience or ignorance. Learning how to activate and deactivate safeties, how to use controls, load and unload, clear malfunctions, and even how to properly clean and maintain your firearms are all essential skills that you must possess and utilize when you handle any firearm.

6. Always use caliber-correct factory ammunition.

First of all, reloaders, don't cast your stones, as this is geared toward the rest of us. Reloading is a skill and should not be taken lightly as it requires specialized equipment and knowledge of all of the different dies, cases, bullets, powders, primers, and the right recipe. For the rest of us, make sure you know the specific caliber/s of every firearm you shoot and of every box of ammunition you obtain. Using factory ammunition or custom handloaded ammunition from a licensed manufacturer ensures that it will be safe to fire in your gun. Factories want to keep selling you ammunition, so they take great precautions to avoid repercussions from damaging your firearm or worse: you. You should also be conscious about that "hot" ammunition you picked up at a gun show from a person you may never see again and also be sure that your specific gun can handle higher pressure ammunition.

There are also guns that can fire multiple cartridges. Revolvers chambered in .454 Casull, .45 Long Colt and .410 shotshell can safely shoot everything from bullets to birdshot, but only because they are chambered that way. It is very easy to slip 16-gauge shells into a 12-gauge shotgun or load a magazine of 9mm into a .40, fire a round, and possibly damage the gun or worse. Pay attention to what you are doing and keep yourself out of a dangerous situation by separating different caliber guns, magazines, and ammo while you are shooting.

7. Use appropriate eye and ear protection.

It's pretty hard to do anything if you can't see or hear. The same applies to shooting. With between 15,000 and 70,000 peak psi inside of a firearm chamber and bore during the burning of propellants, or deflagration, there are many hazards for your eyes. The released gases, unburned powder, and bullet and target fragments are all dangerous to your eyes. There is also great danger to your ears from the noise associated with the pressure release. The average noise level for firearms is between 155 and 160 decibels. To put that in perspective, the average conversation is about 60 decibels, a motorcycle is around 115 decibels, the pain threshold is around 130 decibels, and instantaneous injury or sudden hearing loss comes in at 140 decibels. This all means that when firing even one round unprotected, you run the risk of injuring your eyes and ears. Even with eye and ear protection, there are some large caliber rifles that produce such highly concussive sound waves (which are conducted by the mastoid bone and transmitted to the inner ear) that they can damage your hearing with

Figure 2: Factory-loaded ammunition.

prolonged exposure. A gunsmith should also wear eye protection when working in their shop. Springs and various parts in firearms are under tension and can become dislodged during disassembly, which could be catastrophic if they hit a human eye.

8. Always keep firearms unloaded until ready to use.

Not only is it important to be safe when handling and shooting firearms in the field or at the range, it is equally important to be safe at home and while storing your firearms. Leaving a gun with a round in the chamber in a nightstand is a great way to invite a dangerous situation. Kids are very curious and like to explore; finding a loaded firearm with a safety on won't prevent a child from picking it up and playing with it. If you do keep a firearm loaded for protection, make sure it is out of reach of anyone that you don't want to handle it or isn't trained to handle it, and make sure that anyone you do want to handle it knows that it is chambered with the safety on. Other than home protection, there is absolutely no reason for a firearm to be loaded inside of your house. In fact, there is no reason why your firearms should be stored with magazines and ammunition. By doing so you are just asking for an accident. Storing your firearms and ammunition separately is a good practice. A gunsmith should also implement rules in their shop to help protect themselves. A "no live ammunition at the bench" rule is mandatory as it protects gunsmiths when they do have to violate rule Number 2 in the course of working on a firearm.

9. Learn all that you can about safe handling and shooting.

The phrase "knowledge is power" does not go without merit. Knowledge allows you to handle, manipulate, shoot, deal with malfunctions, and clean a firearm with no risk of danger to you or others around you. Knowing how to be a safe shooter rewards a degree of confidence and assures others they can be confident that

you aren't going to do something that can be dangerous for everyone. It is also important to not only learn everything you can, but also to practice what you have learned and to teach it to friends and family so that they know how to be safe and they can teach others.

10. Do not make firearm safety a secret – Teach others to be safe as well.

Talking about how to be a safe operator and shooter and about being a responsible gun owner to others is a great opportunity to change the mind or opinions of those who frown upon gun ownership. Most people's fears come from ignorance or misinformation, so openly talking about responsible ownership and educating them about safety might be enough to change their minds. You don't have to force your beliefs or opinions on them; just show them that we are responsible, law abiding citizens, exercising our right to protect and defend ourselves and others around us. Provide them with the tools to make an educated decision for themselves.

SHOP SAFETY

There are inherent dangers and risks when working with such powerful machines and sharp cutting instruments. Maintaining a safe attitude and exercising safe practices will ensure your safety. Every time you work with any heavy machinery, make certain you follow these safety guidelines to ensure minimized risk for injury.

- **Safety Glasses** – Anytime you are working with heavy machines and cutting material, you should be wearing safety glasses. In fact, OSHA (Occupational Safety and Health Administration) requires employers to provide workers eye protection whenever necessary. While performing machining on various materials you run the risk of exposure to flying particulate, metal chips, and possibly shrapnel (if a part or tool breaks). You may also need a face shield, hearing protection, and dust mask or respirator (with certain materials like wood or polymer).

Figure 3: Appropriate eye and ear protection.

- **Appropriate Attire** – Your attire may create a high risk for injury. Loose or baggy clothing, long sleeves, untucked shirt, gloves, rings, watches, necklaces and other jewelry may become caught in the machine while it is running, potentially leading to serious injury. Long hair or a beard may also lead to injury if it becomes tangled in the machine. Make certain there is nothing hanging from your person that could become trapped in the machine while it is running.

- **Perimeter** – Create a perimeter around the machine. You want a clear space around the machine so you and the workpiece have room to move freely around it. You will also want to keep the perimeter clear of dirt, debris, chips, and cutting fluid that could cause a slip-and-fall injury. Be sure to have at least a 2 ft. perimeter around all machines.

- **Guards and Safeties** – Do not remove or disable any guard or safety on the machine. They are there for your protection. Disabling safeties and removing guards may lead to an insurance liability if someone is injured, and may void the machine's warranty.

- **Holding and Adjustments** – Tooling (bits and cutters) and parts should be securely held in place while the machine is running, and any adjustments should be made with the machine turned off. If tooling or the part is not secure, you run the risk of damaging the part or breaking the tooling and possibly the machine itself. Tooling should be locked into the chuck or holder and parts need to be clamped to the work table or securely in a jig or vise. To avoid injury, never make any adjustments to the machine or tooling while the machine is running. Make sure the tooling is secure every time you make an adjustment.

Always remember to remove and chuck keys, wrenches, and other tools from the machine before startup. Make sure the machine is turned off before making any adjustments or taking any measurements. Never try to stop the machine by hand while it is running — you will lose every time.

Setting Up Your Shop

Every gunsmith, either professional or hobbyist, needs a place to work and tinker. Professionals, of course, need the shop for their livelihood, and while hobbyists may save a little money on their own gun repairs, their home shop is noted more for the pleasure it offers. When planning a location for a gun shop, you must first decide what type of work you will be performing. For example, if you plan to get your Federal Firearms License (FFL) and work on guns for others, one room or area in the home must be set aside exclusively for the gun business. If it's in the basement, the room cannot also be used for a recreation room. The space must be devoted entirely to gunsmithing business.

On the other hand, if you plan to work on firearms only for yourself, you can locate the "shop" any place you like—even in your own living room.

The average gunsmith will perform a variety of work on firearms, covering the entire field involving troubleshooting, stock finishing, rebluing, stock checkering, firearm cleaning, rebarreling, chambering, soldering, and welding, just to name a few. The ideal shop should be equipped to take care of all these jobs conveniently and efficiently.

This lesson is designed to show you how to equip a gun shop, even if your space is limited. We will begin with the very smallest home shops and progress to shops that are suitable for factory warranty stations and that will accommodate several employees.

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Shop Location

For the aspiring gunsmith who lives in a small townhouse or apartment where space is at a premium, finding a place to set up a suitable workbench is somewhat of a problem. However, many guns have been repaired on footlockers or large toolboxes. One gunsmithing student, living in an efficiency apartment, turned his coffee table into a very functional work center. When the piece of furniture was closed, it was a handsome coffee table that fit in with the room's decor. However, when the top was opened, it revealed an assortment of gunsmithing tools, and the folding wings gave the student a workbench that even boasted a small bench vise.

BASEMENT SHOPS

Most home gun shops are located in the basement. This location has several advantages over other locations, and the few drawbacks usually can be overcome. The chief advantages include these aspects:

- It is cool in the summer.
- It's out of the way of most family activities.
- It's quiet and can be made relatively soundproof from the living area.
- If you have to, you can leave it untidy overnight without worrying about guests seeing it.

The basement area also has several disadvantages, but most of these can be corrected. Most basement areas (as finished by the builder) are poorly illuminated. This gives a dark, dingy appearance. So, if the basement is the area chosen for the shop location, one of your first projects should be the installation of adequate lighting. Fluorescent fixtures are ideal. However, if the basement has an acoustical T-bar ceiling, you may want to go with recessed fixtures—either incandescent or fluorescent.

Figure 4: A gun shop can be set up in your basement, attic or garage; each has advantages and disadvantages.

One of the major disadvantages of a basement is dampness, which, of course, creates rust problems. To overcome this problem, you can apply epoxy waterproofing to basement walls from the inside and then use foam insulating boards to insulate basement walls and check dampness. A good dehumidifier is added insurance.

Flooding is another problem that can be a disaster with some basements. However, if all slopes are graded away from basement walls, all gutters and downspouts are kept in good repair, and an adequate sump pump is installed, the chance of basement flooding is greatly reduced.

ATTIC SHOPS

Attics are probably the worst place to put a gun shop in the home. They are often hot in summer, cold in winter, and short on head room. Add to this the difficulty of transporting materials to and from the attic, plus the noise and vibration that carries down into the living area, and the disadvantages are quickly realized.

Of course, if there is no other place available, these disadvantages can be somewhat remedied. First of all, insulation in the walls, roof, and floor will help to keep a more controlled, comfortable temperature and to muffle noises. An attic ventilating fan will reduce attic temperatures considerably, as will the installation of several windows if they are currently absent.

Noise and vibration produced by power tools can be overcome by mounting them on rubber mats and/or rubber washers. Tightly sealed attic doors will also help retain the shop noises in the attic and cut down on dust escaping into the living area. Outside stairs to the attic also have their advantage.

GARAGE SHOPS

A garage is one of the best places to locate a gun shop. Although garages are often drafty and hard to heat in winter, they can be made into excellent shops having advantages that other areas in the home cannot offer. First of all, a garage shop allows you to work into the early hours of the morning, usually without disturbing anyone in the home. If it is located far enough away from the house and other neighbors, even power tools can be operated without bothering anyone. You do not have to worry about fumes from hot bluing and other operations smelling up the home, and you also do not have to worry if you are faced with leaving a temporary mess.

Even if you still plan to use the garage to park your car(s), there are ways to also use the garage as a shop. For example, the floor plan in Figure 5

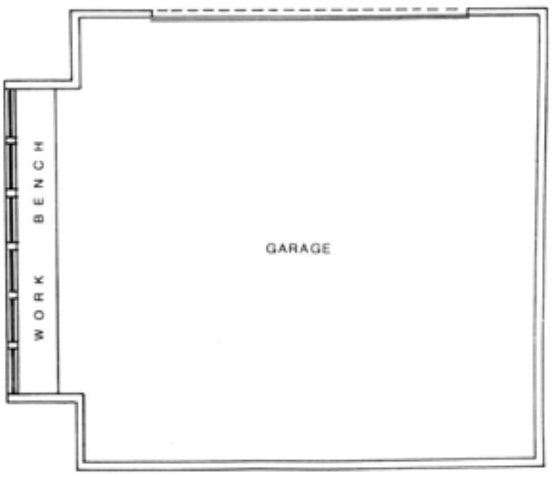

Figure 5: This floor plan of a two-car garage has a large workbench installed in a nook on the side of the garage.

shows a two-car garage with a large workbench installed in a nook on the side of the garage. A hinged, fold-down bench may also be used, but this requires that the bench be cleared before it can be folded out of the way.

The ideal setup is to use one half of a two-car garage as a shop and the other half for parking a car. If you still want shelter for a second car, build a carport — it's much cheaper than building an enclosed shop.

Even if you do not have a garage on your property or you're an apartment dweller with no other possibilities for locating a shop where you live, look around town for the possibility of renting a garage. Then set up your shop in this rented structure and work in your spare time.

OUTBUILDINGS

If your house is small, without a basement, and there is no room in the garage, a separate building may be the answer; you can work late at night or early in the morning without disturbing anyone. A precut garage may be an inexpensive way to get such a shop. Or how about a trailer?

Existing barns and outbuildings may afford prime shop space for those living in rural areas. You may need to install insulation and heating and possibly run an electric service from the house out to the building, but these are only remodeling jobs. Most people would rather remodel than attempt to build from scratch. In some areas, zoning codes may stop you from adding a structure to your property, but an existing structure usually does not pose any problem. However, check with the local building inspector's office just to be sure.

CLOSET SHOPS

With a little ingenuity, an amazing amount of tool storage and workspace can be fitted into a closet. Highly productive shops have been hung on the back of a closet door, with work tables that fold down to reveal an array of hand tools neatly stored on a panel of perforated hardboard. It's not the best solution, but it's a beginning. There may be space under a stairway or at the end of a hall that can provide comparable accommodations.

Figure 6: Closets can create shop space easily with a little creative storage.

PORCHES

Does your home have a porch that is seldom used? If so, you can probably convert it to a very good shop with comparatively little expense. In most cases, the roof, floor, and at least one wall are already there, so all you have to do is fill in the other two or three walls and add a workbench, and you are ready to start working.

Since the walls that are added usually will be exposed to the weather, be sure to insulate well. The floors and ceiling should be considered too. If you cannot get to existing void spaces to install insulation, consider having insulation blown in after boring holes to reach the void spaces between studs.

Conventional framing can be used to enclose the open walls of a porch, but perhaps jalousie windows would provide a better arrangement. A jalousie window consists of a series of operable, overlapping glass louvers that pivot in unison—usually by a crank-and-gear system. Such windows are best used in southern climates where maximum ventilation is necessary and in places where a flush exterior and interior appearance are desired.

Figure 7: Example of small gunsmith shop, built into a shed or garage.

Workbenches

When beginning gunsmiths start to think of graduating from the toolbox/repair kit stage to a full-fledged workshop, their first thoughts should turn to a suitable workbench. Unfortunately, there are not very many commercial workbenches to choose from and those that are available are usually expensive. Therefore, most gunsmiths like to build their own.

In general, a workbench should be 30 in. wide and from 5 ft. to 12 ft. long. However, do not skimp on the length, because you will soon find that there is really no such thing as too much bench space.

The height of the workbench will vary depending on your height. An average-built man might prefer a workbench about 33½ in. high. However, you might want yours anywhere from 30 in. to 35 in. Above all, the bench must be sturdy and firm. You cannot do your best work if the bench moves every time you take a file stroke or tap a drift pin out of its hole. Therefore, the ideal workbench should be amply reinforced, and the legs and top should be made of heavy timber.

In addition to the main workbench, it is nice to have an auxiliary bench for special projects. In small shops, this bench will also suffice as a main bench, and although the legs are constructed of 2 in. by 4 in. studs, the plywood bracing makes it very sturdy.

Note that the frame of the bench in Figure 8 is made entirely of 2 in. by 4 in. studs, reinforced with ⅜ in. plywood. The top is constructed from two layers of ¾ in. plywood glued together. A piece of hardboard nailed with finishing nails

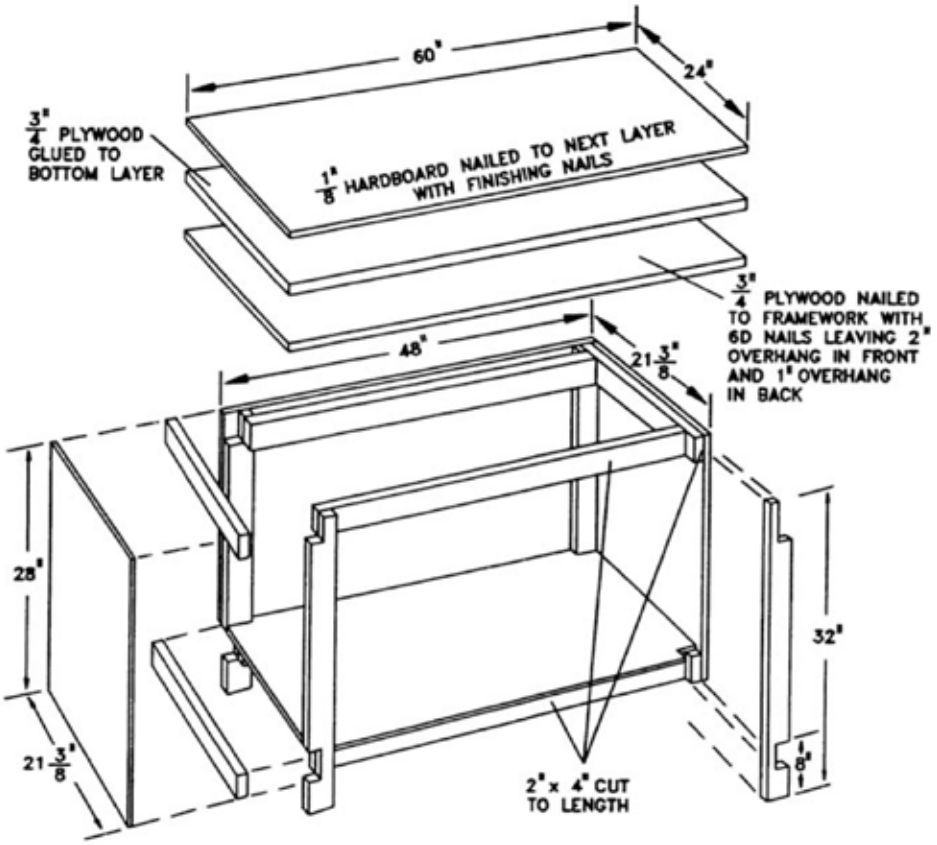

Figure 8: A good basic bench for the beginning gunsmith. As the business expands, and the need for a larger bench increases, the smaller bench can be used as an auxiliary bench.

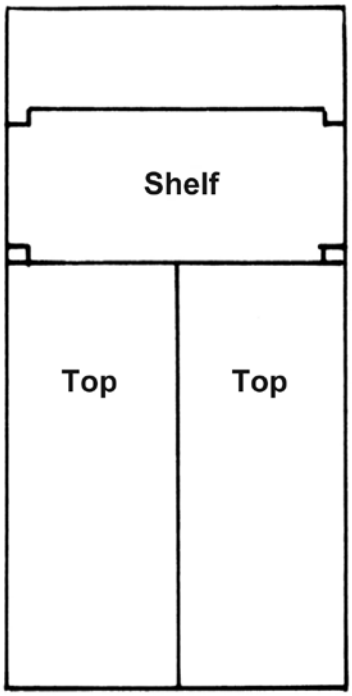

Figure 9: Layout for the ¾ in. plywood for the basic workbench.

to the top protects the bench top and can be changed as often as needed.

You should design your bench or benches to fit into the available space and to serve your own needs. If you are handy with woodworking tools, you might want to build a few drawers for certain tools. If not, you can buy the prefabricated drawers of steel or plastic and install them by screwing the brackets to the underside of the bench top.

To begin constructing the workbench in Figure 8, lay out the top pieces and shelf on a single piece of 4 ft. x 8 ft. x ¾ in. plywood as shown in Figure 9. Use a straightedge and square for the lines, and then cut out the various pieces with a hand or power saw.

Next, cut all 2 in. x 4 in. studs, notching the legs as shown in the exploded drawing in Figure 8. Mark and drill screw holes and then assemble the two end frames with glue and wood screws. You may want to countersink the screw holes for a neat appearance. Join the two end frames with the four long 2 in. x 4 in. studs, again using glue and wood screws.

Insert the lower shelf as indicated after notching all four corners to fit the bench legs. Nail and glue the shelf in place. At this point, the work should be taking the form of a workbench. Continue by marking the cutting diagram on the ⅜ in. plywood for the sides and back — again using a straightedge and square. When they are cut out, nail and glue these panels to the sides and back as shown.

Now nail and glue the lower ¾ in. top panel to the top rails of the frame, followed by the next panel and the sheet of ⅛ in. hardboard (nailed only). Keep all of these panels under pressure (using C-clamps) until the glue dries.

If you prefer shelves over your bench, a shelving unit may be hung on a wall directly in back of the bench or mounted to the bench top. The top, sides, and shelves may be made from ¾ in. plywood or 1 in. shelving boards of a width to suit your needs. A pegboard area is also handy for tool hanging. The overall size of the unit, spacing of shelves, etc., can be varied to suit your needs.

APARTMENT WORKBENCH

Apartment dwellers in cities are usually handicapped by not having sufficient space in which to do gun repairs. However, it is possible to have a complete workshop in a handsome cabinet that looks like a respectable piece of furniture.

The hinged top opens to display an ample assortment of gunsmithing tools, which are held securely in place by hold clips fastened to the bottom of the ¾ in. plywood top. The narrow panel on the front of the cabinet hinges out and up to provide access to the 24 in. x 27¾ in. workbench top, which is supported by rollers fitted into slots, as shown in the drawing. Stops cut from 1 in. x 2 in wood blocks keep the workbench top from coming all the way out from the cabinet, while 2 in. x 2 in. screw-in legs are used to support the work surface (Figure 10).

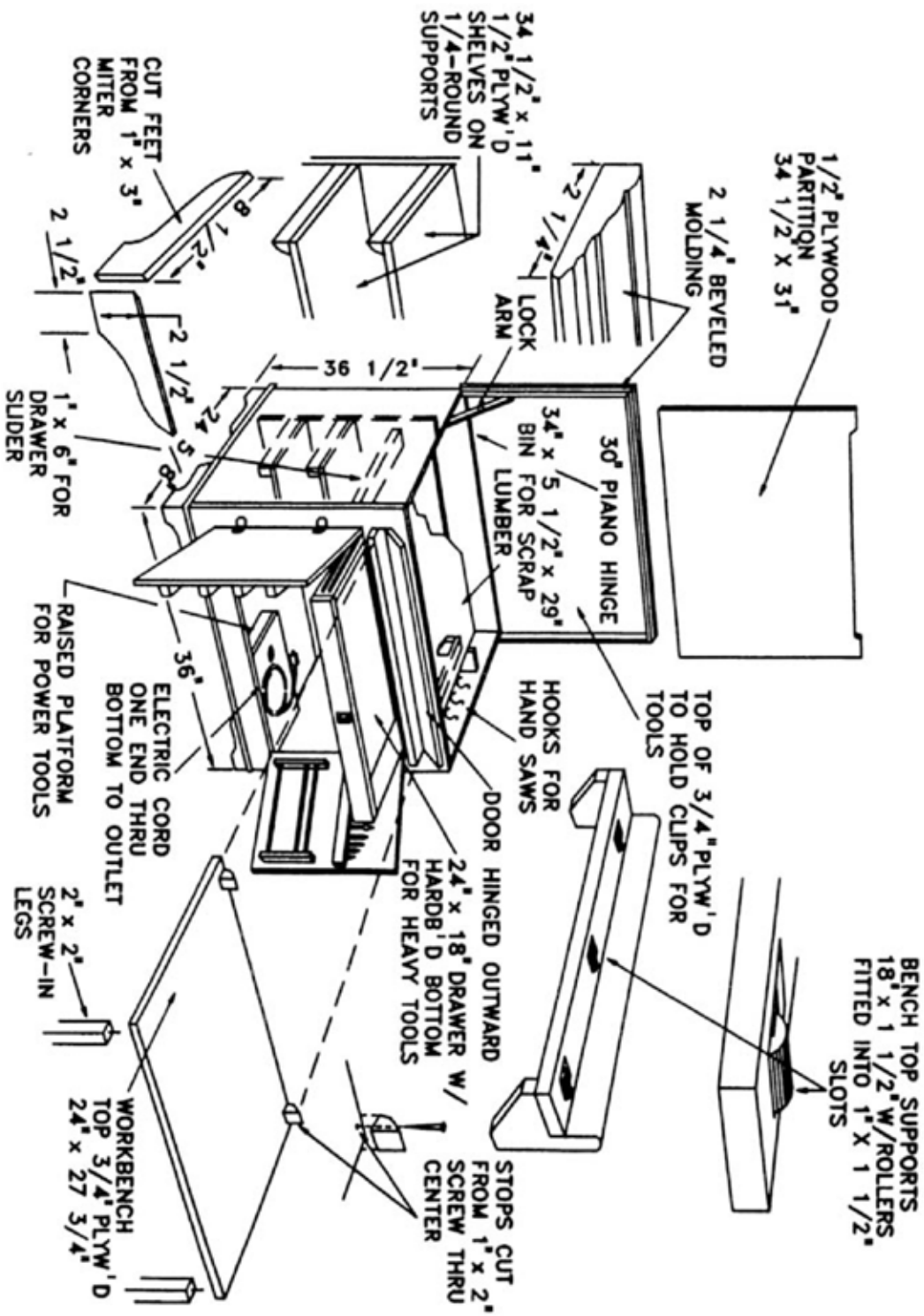

Figure 10: Plans for an apartment workbench.

A raised platform on the bottom shelf of the cabinet can be used to house power tools such as a rotary tool or even a small metal-turning lathe. Note also that an electric power cord runs through a hole cut through the bottom to a power outlet. A 24 in. x 18 in. drawer may be used for other heavy tools while the inner sides of the cabinet doors hold bits, blades, sandpaper, and other gunsmithing supplies.

PLANNING AHEAD

The beginning gunsmithing student or hobbyist will probably start out with the very minimum of tools, but you should remember to start out first with a solid workbench and bench vise; more tools can be added as the need arises. For example, the workshop shown in Figure 5 is a good shop for the beginning gunsmith or hobbyist, and is about the minimum that one can get by with to perform even basic work on guns. Still, you are looking at about a $5,000 or more investment. But if you concentrate only on the bench tops themselves (without drawers), or just one wing of the bench, and add the bench vise along with your basic hand tools and toolbox, you could probably get by for around $500, especially if you are handy with woodworking tools and you can get a hold of some scrap lumber.

At the first opportunity, you would probably want to purchase a drill press and a bench or pedestal grinder that can also be used as a buffer. Sure, your shop is relatively bare at the moment, but you have high hopes of expanding it into the shop shown in Figure 11. Later on, a metal-turning lathe could be placed in back of the operator, opposite the bench containing the drill press, bench vise, etc. Eventually you will have an excellent setup for performing nearly all phases of gunsmithing on a small scale.

If you are planning to expand into a part-time or full-time business, your planning should extend even further. Again, let's deal with the one-person shop layout shown in Figure 11 and see how it can be expanded. This shop could be

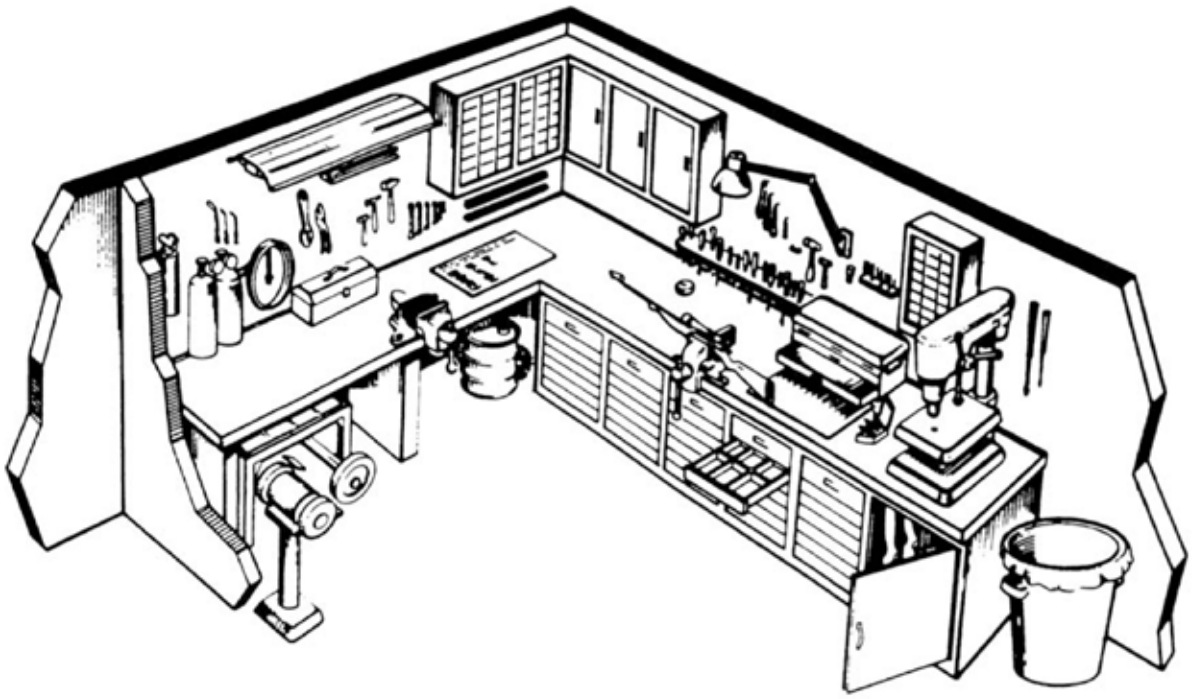

Figure 11: Excellent shop layout for the beginning professional. A metal-turning lathe and milling machine can be added later.

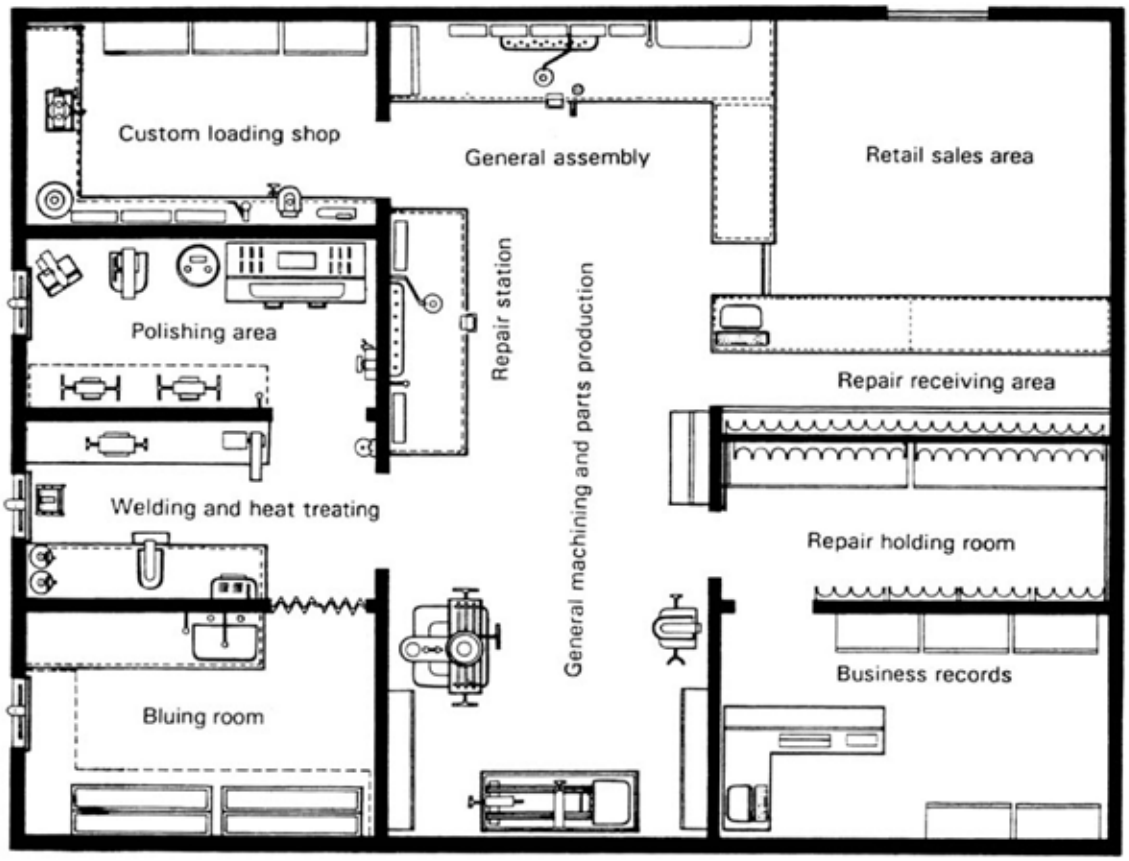

Figure 12: Floor plan layout of an excellent gun shop arrangement for the professional. It is designed to satisfy the means of even the most demanding gunsmith. Three or four workers can easily work in these areas.

one room in the basement of your home or in a two-car garage. While designing your shop layout, assuming that you do have plans for expansion, you should give careful consideration to the first room's location so it may be logically tied in with future expansion, as in the layout shown in Figure 12. This shop layout illustrates machine placement and organization of various shop functions. Close proximity of associated operations enhances productivity in a shop of this type. However, special consideration must be given to separate those activities that require an isolated work area. While it is desirable to separate many incompatible work functions, it is still essential to be able to monitor and control the entire operation at all times.

Note that all operations producing high volumes of air contaminants such as dust, harmful vapors, and excessive heat have been isolated and then further divided into subgroups to aid in containment. To control the dust residue properly in these areas, a high-volume portable vacuum has been centrally located near those machines involved. This unit may be connected directly to the machine in operation or to the vented hoods located above these work areas. To supplement this system, filtered exhaust fans have been installed to maintain a sufficient air exchange rate to ensure proper air filtration. These systems maintain a clean, safe work environment and further serve to reduce cleanup time, which frees the gunsmith to be more productive.

Some gunsmiths feel that a retail sales area is necessary for business; others do not. If a retail sales area is incorporated into the gunsmith's shop, all shop operations that require isolation in a controlled area must be performed when the retail sales area is not accessible to the general public. It is also advisable to install a sensor that is never disarmed during regular business hours — alerting you when anyone enters the premises. This system would permit you to concentrate completely on work operations even when in isolated areas, yet still monitor the retail sales area effectively. In most cases, the retail sales concept is a highly recommended business function that will bring you more customers and generate sales. The benefits of additional sales and higher revenues realized from a retail sales area are apparent. But maintaining and operating this supplemental facility requires additional time, and in a one-person operation, there is no such commodity. Therefore, the time spent maintaining retail sales must provide an adequate return for the time invested to justify the time lost in service and repair.

Please note the selective use of the terms *spent* and *invested*, because you must understand them in order to achieve and maintain both repair service and retail sales. Consequently, you must be qualified to make the distinction between *spending time*, such as discussing what size shot was used to kill that big gobbler last year, and *investing time*, such as recommending the most appropriate scope to mount on that rifle that you just sold.

In other words, spending time usually involves discussions that are unrelated to business. However, investing time involves your offering professional advice and recommendations to the customer, and might be directed toward adding equipment to improve the customer's rifle. Consequently, the gunsmith operating in a one-person shop situation must recognize that "time is money." Time, being a fixed commodity, can neither be replaced nor regained; invest it wisely and it will produce additional revenues.

The only remaining difficulty yet to face will be that time when it becomes apparent that you have applied this principle so well that there is insufficient time to maintain expanded retail sales and complete the contracted repairs. The solution is expansion, a sign of success.

In a one-person shop with consumer access to the display area, you should consider having a controlled shop entrance to separate the shop from the retail sales area. This facility should be designed and constructed to restrict customer access and discourage unsolicited observers. In addition, the gunsmith will need to develop an effective, but diplomatic, means of retreating to this area to resume his or her work but still leave the retail customer with a sense of a successfully completed transaction.

Shop Layout

Bluing Room. This room is one of three rooms separated from the general repair area by one common access to help contain airborne contaminants. The bluing room, shown in detail in Figure 13, is further isolated from other work areas by a vented barrier, which prevents harmful oxidizing vapors from circulating through the shop. Heated bluing tanks are situated below a vented hood, which further aids in trapping both heat and fumes, and a filtered exhaust fan provides sufficient air exchange to clear the bluing booth. An adjacent work counter provides an adequate holding area for both polished and blued parts and contains a water supply and drain for convenience. A central air jack is provided to aid in clearing residue from parts in various stages of the bluing process. See Figure 14 for a cutaway view of the bluing area, as well as the business records, welding, and custom loading areas.

Business Records. This area is organized around a business computer with basic accounting capabilities, including general ledger and accounts payable and receivable and integrated systems for inventory control. Ample file storage is provided for business and Bureau of Alcohol, Tobacco, and Firearms (ATF) transaction and file records.

Welding and Heat-Treating Area. This area is equipped with a heavy-duty bench vise mounted on a counter facility that is designed for welding and metal fabrication. Both electric and gas welding units are available. Above this work area, a ventilated hood fitted with a powerful exhaust fan vacuums smoke and harmful fumes generated by welding, forging, and hardening operations. On the opposing wall, a work counter supports a bench grinder and a hard wheel belt sander that are used for shaping and finishing. Mounted on the adjacent wall is a spindle grinder/polisher, which is useful in finishing an inside gun radius. Between the counters, mounted securely in concrete, stands a heavy-duty barrel vise for barreling operations.

Custom Loading Shop. Serving a dual function, this area accommodates special loading equipment, including single-stage and progressive presses, powder scales, powder measure, and vibrator/polisher, all selected to fill your specific requirements. Also, this area houses reference storage files, which include loading data and records, service records, gunsmithing references and techniques, and manufacturers' updates. The

Figure 13: The multi-tank bluing setup is the most professional way to go about any hot-bath operation.

loading facility may be expanded from in-house loading to custom or production loading, which would involve additional licensing requirements if loaded for resale. The process would be classified "manufacturing" or "remanufacturing" depending on your source of cases.

General Assembly. The primary work function performed in this area is reassembly. This workstation is designated for assembly of firearms that come from holding areas and require additional downtime for refinishing and customizing or for delayed assembly that requires ordering or parts fabrication. The holding fixture is centrally mounted on a workbench with a generous layout area for reassembly. This design is equally well suited for its secondary function of scope mounting and boresighting.

General Machining. This area contains the stationary machine tools required to perform those basic and most commonly required machine operations associated with gunsmithing. First is a variable speed precision drill press fitted with appropriate holding fixtures, including an angle vise and a supplemental support cradle to execute the required drilling operations. Second is the lathe with a recommended bed length of not less than 36 in., which would be required to perform fitting operations on longer barrel blanks. Also, to avoid restrictions when turning basic diameter blanks, the recommended minimum hole size in the headstock would be 1⅜ in. Finally, the milling operations are adequately handled by a combination horizontal/vertical machine that affords the necessary flexibility to perform the variety of milling operations required. Located near each piece of specialized equipment is a storage cabinet that houses associated accessories, gauges, and tools.

Polishing Area. This isolated work area contains equipment used for surface preparation and

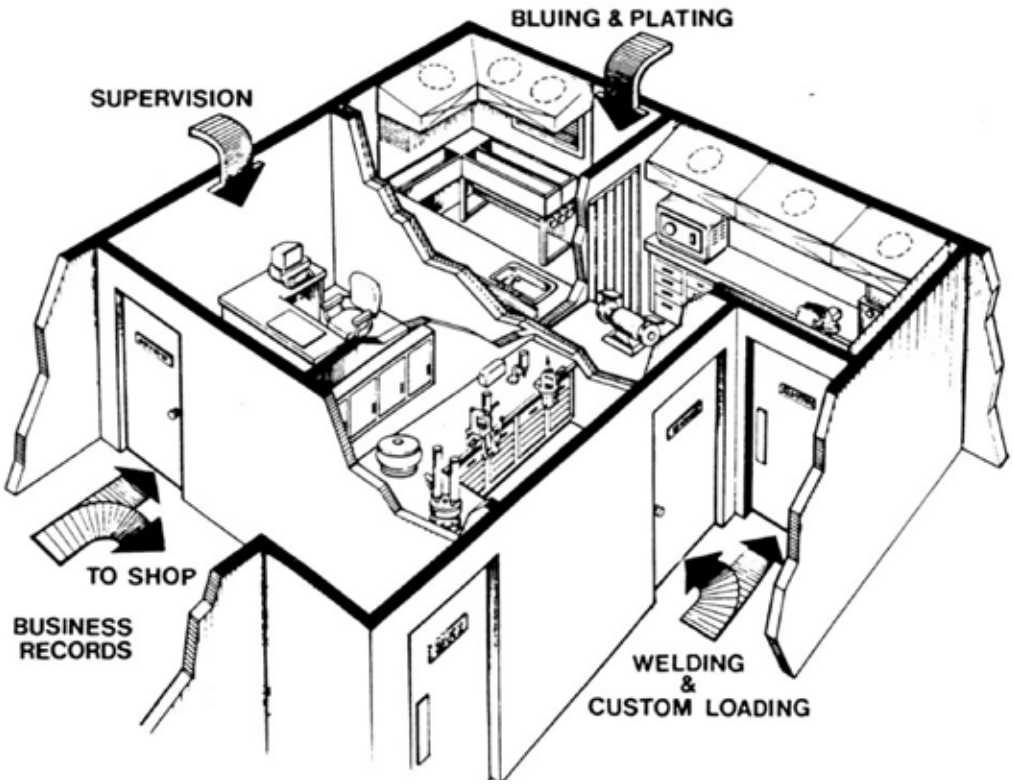

Figure 14: The cutaway view of four important areas in the professional gun shop: business records, bluing and plating, welding, and custom loading.

refinishing, which produce high levels of dust. These machines include both buffers and grinders positioned beneath a vented hood to help trap residue dust. To supplement the polishing, an enclosed abrasive blasting cabinet is available that features an external access. Additional equipment includes a vertical belt sander, a band saw, and a belt/disc sander, all of which incorporate a vac/vent. This feature allows a portable vacuum to be connected to these machines when in use to help control dust emissions. These systems, in conjunction with the large filtered exhaust fan, provide a sufficient air exchange rate to ensure a dust-free atmosphere.

Repair Holding Area. This section is set aside as a storage area for repair work. Divided into two areas, this system separates the repaired guns from those waiting for repair. Space is used efficiently by employing racks to hold long guns and adjustable-hook wall boards to hold pistols and revolvers. This orderly system permits close monitoring, aids in maintaining accurate records (a federal requirement), and alerts you when repaired guns are not picked up on time. Remember, time is money, and repaired work not picked up promptly idles your working capital and eliminates the profit on that repair work. Therefore, to avoid delays in payment, adopt a systematic notification system and maintain it.

Repair Receiving Area. This is a display case fitted with a padded or carpeted top for protection that is positioned adjacent to the general repair area. This location allows the gunsmith to remain in his or her work area while logging in guns for repair. This precludes the need to move from one area or department to another, a problem addressed earlier in this section.

Repair Station. This primary work area centers around a bench vise fitted with padded jaws. This holding fixture is mounted on top of a work counter that houses multiple drawers to provide storage for both tools and parts. A machinist's storage cabinet containing precision instruments is positioned on the counter and is easily accessible from the workstation. Frequently used hand tools are arranged on peg board panels or are stored on open racks for convenience and easy access. The recessed florescent lighting is supplemented by high-intensity boom lights situated above the workstation. Also suspended above the bench is a motorized grinder with a flexible shaft, featuring dual hand and foot controls. To facilitate cleaning, a terminal air jack with a self-coiling hose is suspended from the ceiling. To the rear of the work area, a heated, dust-free cabinet serves as a drying booth for stocks.

Retail Sales Area. This area is enhanced by lighted display counters with key-operated, sliding doors, accessible only from the rear for added security. This style of showcase offers an effective visual display and will undoubtedly increase retail sales, but the glass counter surface will require constant protection from breakage. It is possible to pad or carpet this surface permanently; however, padding will virtually eliminate the uppermost shelf from view, which normally generates 60-65 percent of the total sales volume in this style case. An alternative

Figure 15: Retail sales are increased with proper display cases.

would be individual foam-backed counter pads that could be placed on the showcase when handling or displaying firearms above it, then subsequently removed. This style counter cover has been available from firearms manufacturers and offered to dealers as sales/service aids. A controlled access is centrally located between the showcases that form a perimeter to the retail sales area. This access permits you to enter the sales area but restricts consumer traffic from the work areas. You may conduct business efficiently in this well-designed layout. The lighted cases will display handguns, cutlery, and accessory items effectively and will provide the needed security required for these articles. Ammunition, reloading components, and additional shooting supplies may be arranged on shelving positioned on the wall behind the display cases. Above this shelving, long guns may be arranged on racks. This display is greatly enhanced by thoughtful arrangement, including appropriate grouping, proper identification, and correct tagging and pricing.

PRODUCTION SHOP LAYOUT

The floor plan in Figure 16 establishes machine placement and also illustrates appropriate separation of various shop operations. While some work studies indicate that placing machines close together enhances productivity, special consideration must be given to those activities that produce undesirable by-products like high levels of dust, intense heat, or excessive noise. It is essential, if not critical, that these by-products be controlled effectively.

Note that all dust-producing equipment has been isolated in one section and then further divided into subgroups (areas I, K, L, P, and W) to promote a more effective use of that equipment. To control the dust residue properly, a high-volume central vacuum system is used along with receiver ducts located on or behind each machine. Vented hoods are used in areas where operations produce the highest volumes of air contaminants (A, I, L, K, and V). To supplement these systems, filtered exhaust fans have been installed to maintain a sufficient air exchange rate and ensure proper filtration. The benefits derived from the installation of these systems are threefold:

- They provide for a safer work environment.
- They extend the productive life of the equipment.
- They enhance the total efficiency concept in production.

As indicated by points E, S, and F in Figure 16, shop access from the retail sales area is restricted to employees only.

Also, note that the custom shop is centrally located but is separated from the associated areas. This arrangement allows immediate access for the supervisor gunsmith to all departments, which facilitates custom work while allowing for proper supervision.

The warranty service area is another optional expansion area that promotes high-volume repair and provides direct access to the manufacturer with higher discounts on parts acquisition. Direct access to the consumer through warranty repair provides yet another opportunity to expand sales through associated services.

The custom loading area may be considered optional and, if expanded to include production loading, would require a separate license and should be maintained through controlled access. The options involve the type and volume of loading, which could be summarized as high-volume production loading, specialized custom loading, or simple in-house loading for a specific requirement. Regardless of the application, immediate access to a loading facility will prove to be invaluable. For example, you may be required to test an obsolete rifle for which ammunition is no longer made. A custom loading facility would give you the tools to reload such ammunition right in your own shop.

Area Identification Legend

A. Bluing and plating room ***
B. Business records
C. Controlled access to bluing and welding area
D. Controlled access to reloading area
E. Controlled access to retail sales area
F. Controlled access to shop area
G. Custom loading shop ****
H. Custom shop
I. Custom stock alteration and design
J. General machining and parts production areas
K. Hooded and vented spray booth
L. Polishing area
M. Repair station #1 **
N. Repair station #2 **
O. Shipping and receiving ***
P. Stock alteration and final finish ***
Q. Supervision
R. Synthetic stock alteration and design ***
S. Warranty records
T. Warranty repair area
U. Warranty repair station *
V. Welding and heat treating
W. Woodworking
AA. Workstation #1 ***
BB. Workstation #2 ***
CC. Workstation #3
DD. Workstation #4 ***
EE. Workstation #5 **
FF. Workstation #6 **

* with under-counter parts storage
** with under-counter tool storage
*** with under-counter supply storage
**** with under-counter component and die storage

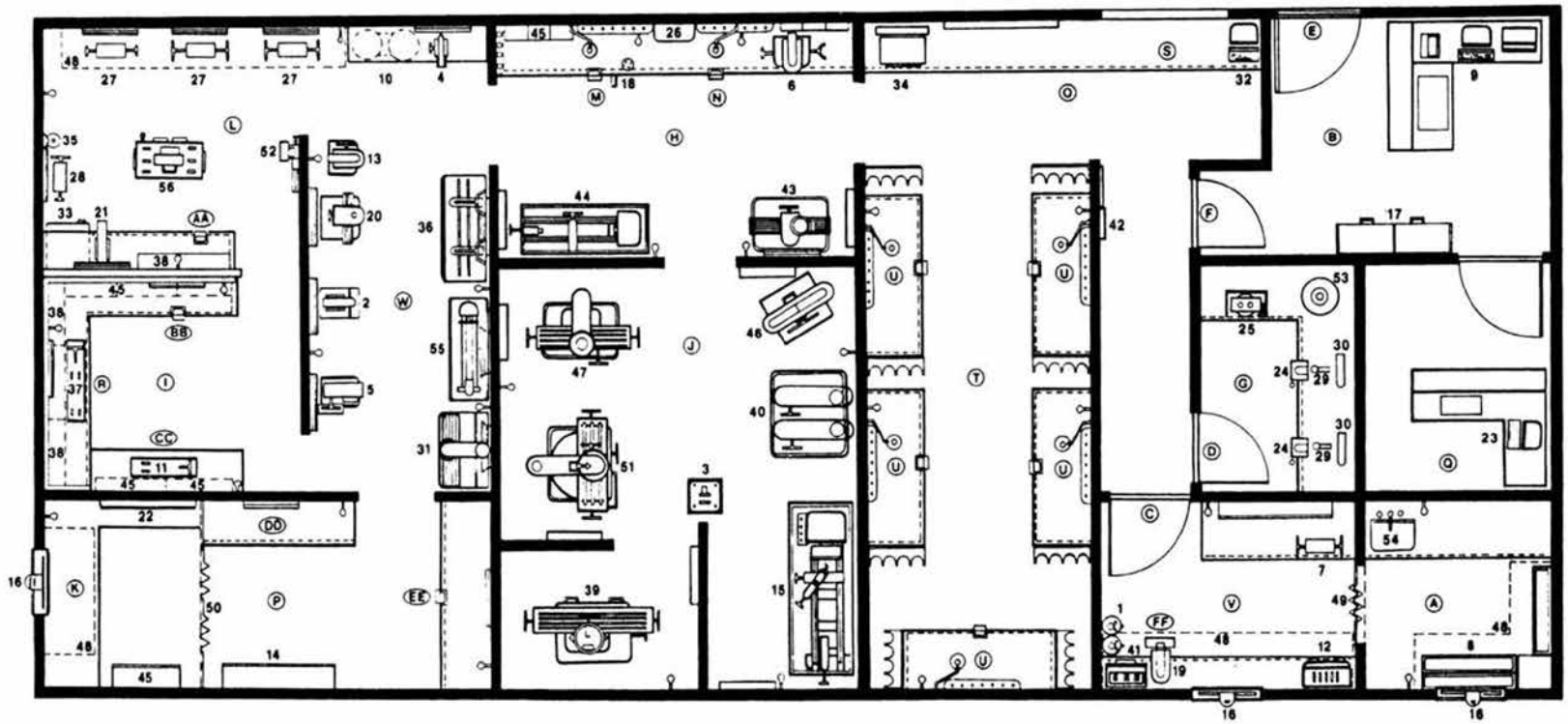

Figure 16: Floor plan layout of a modern production gunsmithing facility.

TOOL AND EQUIPMENT LEGEND

The tools and equipment, designated by numerals on the floor plan in Figure 16, are as follows:

1. Acetylene and oxygen tanks
2. Band saw
3. Barrel vise
4. Belt/disc sander, 1 in.
5. Belt/disc sander, 6 in.
6. Bench drill press (with support cradle)
7. Bench grinder
8. Bluing tanks
9. Business computer terminal
10. Central vacuum
11. Checkering cradle
12. Cyanide furnace
13. Drill press (floor model)
14. Drying cabinet
15. Engine lathe (50 in. centers)
16. Exhaust fan
17. File storage
18. Foredom grinder (overhead)
19. Heavy-duty bench vise
20. High-speed wood mill
21. Hard wheel belt sander, 2 in.
22. Holding area rack
23. Inventory control computer terminal
24. Loading press (metallic)
25. Loading press (progressive)
26. Machinist's tool chest
27. Pedestal buffer
28. Pedestal grinder
29. Powder measure
30. Powder scales
31. Radial arm router

Figure 17: Adjusting vernier on a lathe.

32. Recordkeeping computer
33. Refrigerated storage
34. Shipping equipment and scales
35. Spindle grinder/polisher
36. Stock duplicator
37. Stock vise
38. Supply storage
39. Surface grinder
40. Tandem drill presses
41. Tig welder
42. Time clock
43. Tool-and-cutter grinder
44. Toolroom lathe
45. Tool storage
46. Variable-speed drill press
47. Variable-speed vertical mill
48. Vented hood
49. Vented bluing booth barrier
50. Vented spray booth barrier
51. Vertical/horizontal mill
52. Vertical belt sander, 2 in.
53. Vibrator/polisher
54. Water supply
55. Wood lathe

CUSTOM SHOP DETAILS

The cut-away aerial perspective view of the custom shop in Figure 18 illustrates the general layout of the two repair stations. Vises are mounted on top of the work counters housing multiple drawers and storage areas. These units, originally designed as printers' type storage cabinets, were selected because they provide a lot of storage area for both tools and parts. The compartmented drawers are individually labeled, provide for excellent separation and identification, and are ideally adaptable to our requirements.

A machinist's storage cabinet containing precision instruments is positioned on the counter between the two workstations, allowing access to both. Frequently used hand tools are arranged on pegboard panels or are stored in open racks for convenience and easy access. High-intensity boom lights situated above the counters supplement the lighting for the workstations. A motorized grinder with a flexible shaft and dual controls is suspended from a transverse rail by a spring mount. Also, a central air jack coupled to a coiled hose is suspended from the ceiling.

Other major equipment includes a bench model variable-speed drill press fitted with a supplemental support cradle (which will be discussed in the next lesson). A tool room lathe is positioned in the immediate area for small parts production and equipment maintenance. A tool-and-cutter grinder is also available to produce and maintain special tools and cutters required in both general gunsmithing and custom work. Located near each piece of specialized equipment is a storage cabinet housing associated accessories, gau ges, and tools.

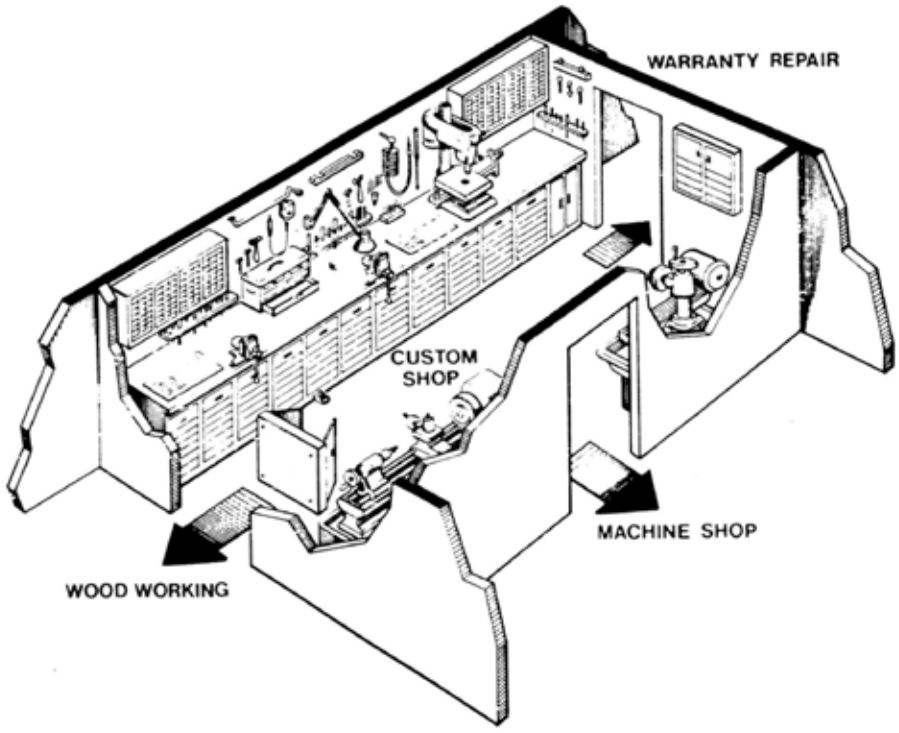

Figure 18: Cutaway view of gunsmith's custom shop.

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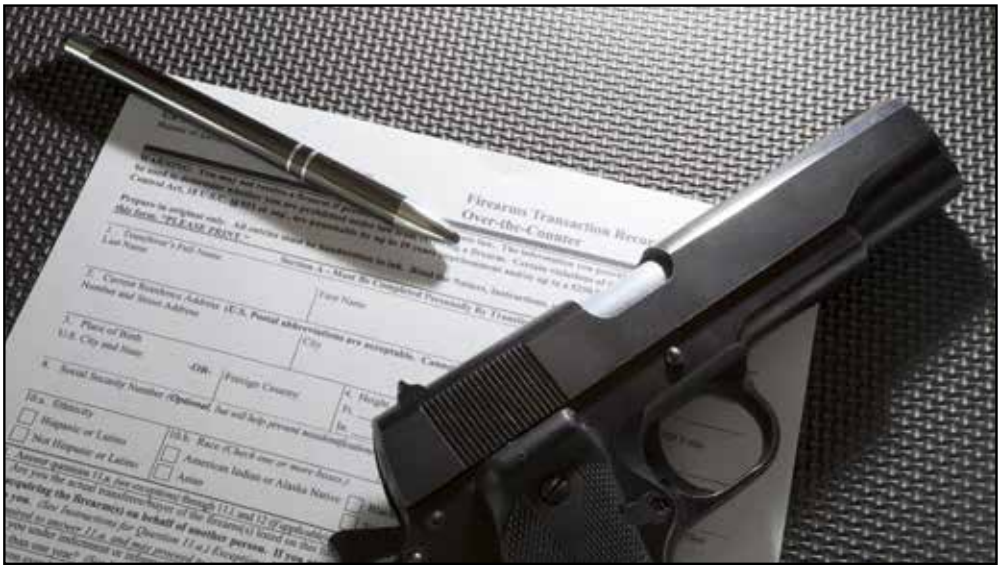
Applying for your Federal Firearms License

There are certain firearm regulations that you should be aware of before getting involved with gunsmithing. In some cases, grief has come in the form of ten years or more in prison for some otherwise innocent citizens who were unfortunate enough to get caught in a firearms violation. Do not let this happen to you. Abide by all firearm regulations. However, antique firearms and modern black powder muzzleloading firearms do not fall under the current federal firearms laws.

In general, the law allows you to work on your own firearms any time you wish. But if you work on another person's guns, even just cleaning them, you must have a Federal Firearms License (FFL) or else work for someone who has one. To qualify for the license, you must:

- Be 21 years of age or older
- Not be under indictment for, or have been convicted of, a crime punishable by imprisonment for a term exceeding one year (except for business offenses or misdemeanors that do not involve a firearm or explosive and are punishable by a term of imprisonment of less than two years)
- Not be a fugitive from justice
- Not be an unlawful user of or addicted to marijuana or any depressant, stimulant, or narcotic drug
- Not have been adjudicated as a mental defective or have been committed to a mental institution
- Not be an alien
- Not have renounced United States citizenship
- Not have willfully failed to disclose any material information or made any false statement as to any material fact in connection with an application for a federal dealer's license
- Have premises from which you conduct business or from which you intend to conduct a dealer's business within a reasonable period of time

Besides permitting you to work on firearms for others, this license also allows you to buy and sell firearms and ammunition at wholesale or retail to residents of your state. Depending on state laws, sales to residents of adjoining states may be permitted. The business may be located in a garage, an outbuilding, or a regular place of



business, but must be open to the public during the hours you specify on your application.

To apply for a firearms license, you may visit the website at www.atf.gov to download the application or you may call the Bureau of Alcohol, Tobacco, Firearms and Explosives (ATF) Licensing Center at ((800) 800-3855. In most instances, you will receive a voicemail message requesting your name and mailing address. Please make sure that you request an application for Federal Firearms License (FFL) under U.S.C. Chapter 44, Firearms.

The following types of Federal Firearms Licenses are available:*

Type 01 - DEALER IN FIREARMS/ GUNSMITHING
(buy, sell, & repair) Application fee and the first three years is $200. Renewal every three years is $90.

Type 02 – PAWNBROKER
Application fee and the first three years is $200. Renewal every three years is $90.

Type 03 - COLLECTOR OF CURIOS AND RELICS
Application fee and the first three years is $30. Renewal every three years is $30.

Type 06 - MANUFACTURER OF AMMUNITION FOR FIREARMS
Application fee is $30 for three years.

Type 07 - MANUFACTURER OF FIREARMS / AMMUNITION *(buy, sell, repair, assemble, & manufacture)* Application fee and the first three years for Type 07 is $150. Renewal every three years is $150.

Type 08 - IMPORTER OF FIREARMS / AMMUNITION
Fee is $150 for three years.

Type 09 - DEALER IN DESTRUCTIVE DEVICES
Fee is $3,000 for three years.

Type 10 - MANUFACTURER OF DESTRUCTIVE DEVICES
Fee is $3,000 for three years.

Type 11 - IMPORTER OF DESTRUCTIVE DEVICES
Fee is $3,000 for three years.

**Note that application fees are current at time of printing. Check with ATF to verify fees and renewal periods.*

If you qualify, you will receive your license in approximately three months after mailing the completed application and fee. The original license should be displayed, unsigned, in your place of business. Have several copies of this license made and send a copy with an original signature to each supplier when placing an order. When requesting catalogs, also send a signed copy of this license, since most suppliers require proof that you are entitled to a trade discount. Do not photocopy your signature; sign each copy individually.

Your license covers operations only at the location shown on the license. The ATF will send a renewal application about 60 days before the expiration date shown on your license. If you do not receive a renewal application 30 days or so before the expiration date and you want to remain in business, notify the ATF regional office immediately.

To renew your license, complete and send the application and fee to the ATF before the expiration date. You may operate until your new license is received, even though the expiration date has passed.

Gunsmiths, like firearms dealers, must maintain a separate permanent record of all firearms received and disposed of, including firearms received for repair. They must be logged in and out using a firearms acquisition and disposition record. A comprehensive book explaining what is required of a dealer, which records are necessary, and how to prepare them will accompany your license.

The Basics of Handguns, Rifles, and Shotguns

What is the difference between pistols, rifles, and shotguns? What is the difference between lever- and semi-automatic action or what is a two-stage, single-action trigger? There is an overabundance of firearms of different types, with different actions and modes of operation from manufacturers all over the world. It would be a huge undertaking to learn how every firearm ever made works, but understanding the types of firearms, actions, and modes of operation will provide a foundation of understanding if you ever come across a firearm you have never seen before. This information will also make you safer.

Understanding firearm basics will allow you to safely load and unload any firearm you may encounter as well as activate and deactivate any safety. You will also be able to observe, fix, and diagnose any further malfunctions the firearm may experience under normal use. This information will help with service and maintenance of most firearms. You do not have to be an expert on every make and model of every type of firearm available, as long as you have an understanding of the "basics." And remember to always follow all safety rules when handling any firearm.

CYCLE OF OPERATIONS

Almost every firearm functions in the same basic manner. The differences between these firearms is based on how each one of the steps is accomplished. These steps or "cycle of operations" can be accomplished either manually or automatically. The means by which these cycles are completed define both the type of action and operation. These steps include feeding, chambering, locking, cocking, firing, unlocking, extracting,

Figure 1: Different types of pistols, rifles, and shotguns.

Figure 2: The feeding step of the cycle of operations.

and ejecting. Every firearm will perform these specific cycles either manually or automatically, but may not be specifically in this order.

- **Feeding** – The feeding step in the cycle involves transferring a cartridge from the breech of the firearm into the chamber. This can be accomplished in a few different ways. The cartridge can be introduced manually, by inserting a new round into the breech, then manually manipulating the action, driving the round into the chamber. Typically, the bolt or breechblock will push the round through a guide or feed ramp, which makes the cartridge's transition into the chamber much smoother.

  A firearm equipped with either a fixed or detachable magazine will store and feed new cartridges. The bolt or slide will strip a new cartridge from the magazine and push it through the guide or feed ramp into the chamber. Once the round is fired, the firearm will cycle and feed a new round from the magazine into the chamber. The magazine will continue to feed new cartridges until it is empty, at which point it will typically lock the action open.

  Some action types and firearms equipped with a tubular magazine below the barrel rely on a "lifter" or elevator to raise the new rounds up, into the chamber. The elevator will rise and fall as the action cycles. When a round has been fired, the elevator will fall to get out of the way of the extracting/ejecting case. A new cartridge will land on the elevator and it will rise into the path of the bolt or breechblock. The bolt will strip the round off of the elevator and force it into the chamber.

  The feeding step of a revolver works on the same basic principle, but happens

much differently. After the cylinder is loaded and closed, either the trigger is squeezed or the hammer is cocked. As the trigger is being squeezed or the hammer cocked, a small hand will act upon a part of the cylinder and cause it to rotate. As rounds are fired, the cylinder will continue to rotate and align new cartridges with the barrel in preparation for firing.

- **Chambering** – The chambering step in the cycle involves fully seating the cartridge into the chamber. Again, this can be done manually or automatically. The bolt/breech face/slide will push the round completely into the chamber. The chamber and bolt will form a container that fits the size and shape of the round and completely encapsulates the cartridge. With revolvers, the rounds are chambered when the gun is loaded. Each individual chamber is loaded with a new cartridge before the cylinder is closed. New rounds are chambered again when the cylinder rotates and aligns with the barrel.

- **Locking** – The locking step in the cycle of operations secures the chamber closed during the firing process. This is accomplished in one of two ways depending on the type of action being employed. The chamber can be physically locked by some type of mechanical means like locking lugs or breechblocks or simply forcefully closed by the inertia in the bolt/breechblock/slide and recoil/return spring.

  Locking the chamber mechanically involves the bolt/breechblock/slide to align with a corresponding locking surface on the barrel/barrel extension. This can happen in various ways depending on the action and operation type. Typically, breechblocks will move up or down into locking recesses in the receiver, while bolts may also move up or down into locking recesses or lock in line with the

Figure 3: The chambering step of the cycle of operations.

Figure 4: The locking step in the cycle of operations.

barrel or rotate to align locking lugs. During firing, the back thrust of the cartridge from internal pressure forces the surfaces of the bolt/breech/slide against the surfaces of the barrel/receiver. The chamber will stay locked until it is safe to unlock. Mechanical locking chambers are typically reserved for most pistols, rifles, and shotguns.

Revolvers lock mechanically, but much differently than other firearms. As the cylinder spins and comes into alignment with the barrel, a part called the *cylinder stop* will engage a corresponding notch in the cylinder. When the cylinder stop engages the notch, it will lock the cylinder in place, in alignment with the barrel. The locking step typically happens in conjunction with the cocking step.

Blowback actions rely on inertia and friction to lock the breech until pressure has dropped enough to safely open. The weight of the bolt/slide and the strength of the recoil/return spring, combined with the friction between the cartridge case and chamber, resist the back thrust of the discharging cartridge. Blowback actions are typically reserved for rimfire and low energy pistol cartridges.

- **Cocking** – The cocking step in the cycle of operations sets the fire control group components to the "cocked" or ready-to-fire position. This can happen in various ways depending on the type of fire control group employed. The firearm may use either a hammer and firing pin, or striker. The mechanism may be cocked either manually or automatically depending on the action.

Figure 5: The cocking step in the cycle of operations.

The hammer or the striker is under constant load from its respective spring. When the action cycles (manually or automatically) the bolt/breech/slide will set the hammer or striker to the cocked position and compress the spring. Most hammers will cock on the rearward movement of the action, while most strikers will cock on the forward movement. A part called the sear is used to trap the hammer/striker in the cocked position. When the hammer or striker is cocked, the sear will engage a corresponding sear surface or hook on the hammer or striker. The spring will try to force the hammer/striker forward, but the sear will arrest any movement. When the sear is moved during the firing sequence, the hammer/striker will be free to move forward.

Some action types may require you to manually cock the hammer using a protrusion on the rear of the hammer called the spur. Other action types will only allow you to cock the hammer through the trigger squeeze. Some striker fire firearms will set the striker into a "set" position without fully being cocked. The trigger must be moved a small distance to fully cock the striker.

- **Firing** – The firing step in the cycle of operations releases the hammer or striker and creates ignition of the cartridge. Firing requires manipulation of the fire control group to release the hammer or striker. When the trigger is pressed to the rear of the firearm, the hammer or striker will be released from the sear by mechanical linkage.

  The firing step of the cycle of operations has its own specific sequence. When the hammer or striker are released from the sear, their respective spring forces them forward. The hammer will hit the rear of the firing pin, driving it forward into the primer of the cartridge. The striker will fly forward, striking the primer (Figure 6a).

  When the primer is struck, a very sensitive (primary) explosive is ignited. Primary explosives are extremely sensitive to ignition from impact, friction, heat, static

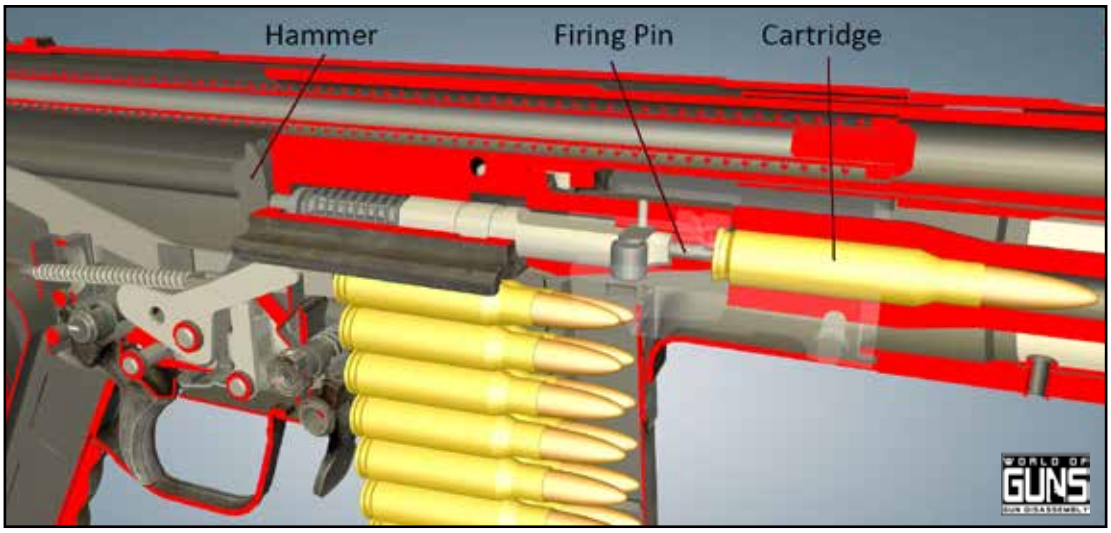


Figure 6a: Striker or firing pin striking the primer.

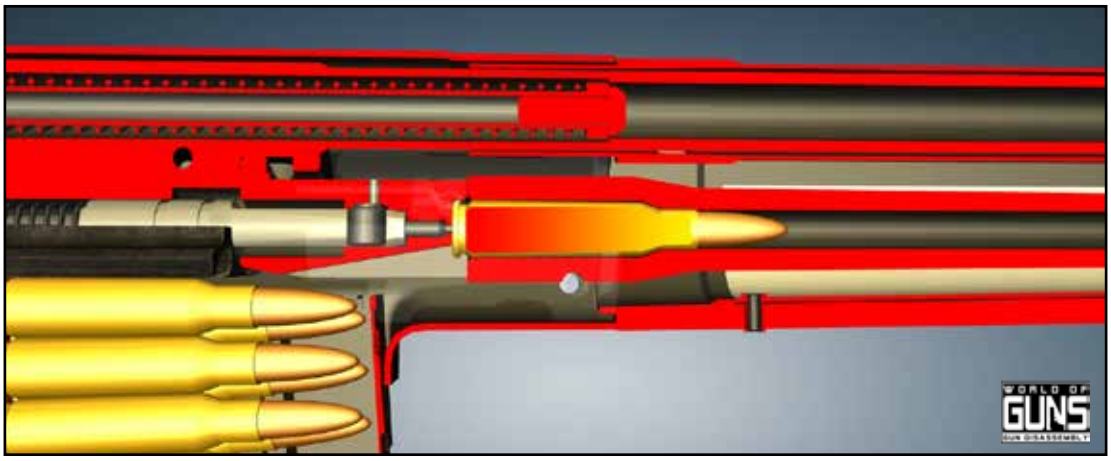


Figure 6b: The priming compound is ignited and travels to the propellant.

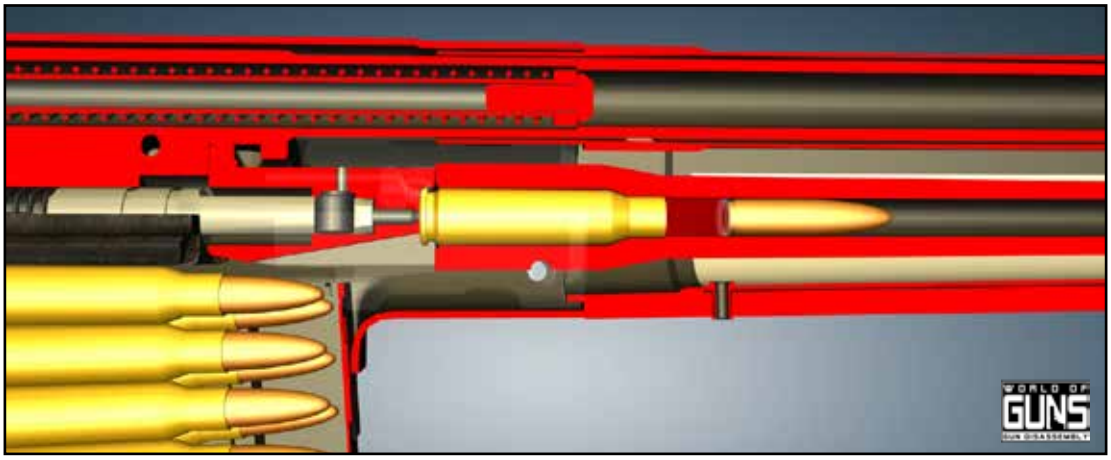


Figure 6c: Pressure builds inside the cartridge case.

electricity, or electromagnetic radiation. In the case of cartridge primers, impact creates ignition. When the firing pin impacts the primer cup, the priming compound is crushed between the primer cup and the anvil. When the priming compound is ignited, burning embers and incandescent particles travel from the primer through the flash hole and onto the propellant. Note that there is no flash hole with rimfire cartridges; the embers travel straight to the propellant (Figure 6b).

The embers from the primer ignite the propellant in the body of the case. The propellant begins to burn (deflagrate) and produce rapidly expanding hot gas. The expanding gas begins creating pressure, which begins acting against the case. The soft brass cartridge case begins to expand and seal (obturate) the chamber from the breech. Once the case has fully formed to the chamber walls and has no more room to expand, the gas begins to act against the bullet. The pressure will begin to force the bullet from the crimp in the mouth of the case into the bore of the barrel (Figure 6c).

The bullet is forced from the cartridge case into the throat of the chamber and onto the leade (lead). The leade will guide the bullet into the bore and rifling. As the bullet begins to travel through the bore, the rifling will begin to impart spin onto it. The pressure will continue to build as the remaining propellant burns until all of the propellant has ignited. The pressure will force the bullet from the bore and out of the muzzle. Any residual propellant or pressure in the bore will follow the bullet out of the muzzle.

As pressure drops inside the bore and chamber, the case will begin to contract and open its seal against the chamber. When the pressure inside of the bore and chamber equalizes with atmospheric pressure conditions, the breech becomes safe to unlock. The case is also ready to be extracted from the chamber. At this point, depending on type, the action can/will complete the next step of the cycle.

With revolvers, much of the firing sequence is the same up to the point where the bullet is pushed from the cartridge case. Once the bullet leaves the case, it is forced through the forward portion of the cylinder. The projectile will then have

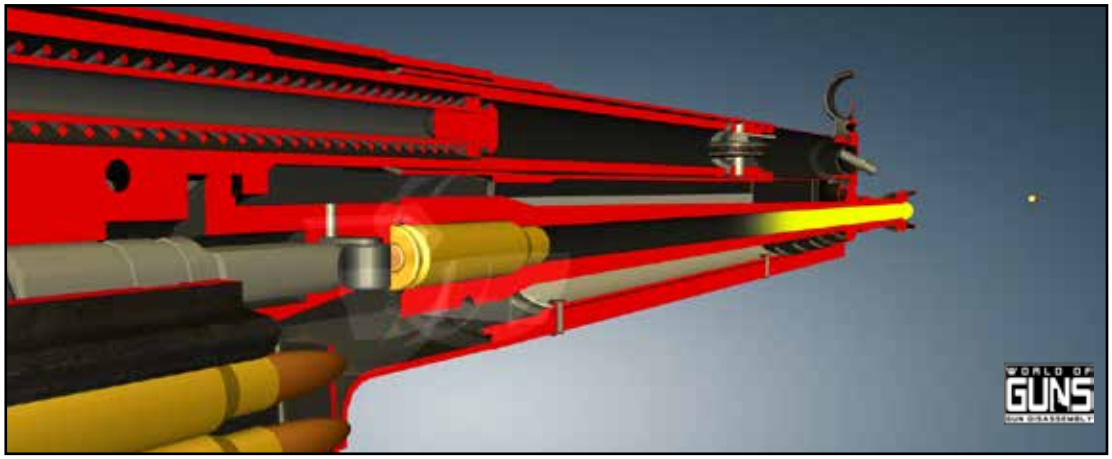


Figure 6d: The bullet is forced through the bore and out of the muzzle.

Figure 7: The unlocking step in the cycle of operations.

to pass through the cylinder gap. The cylinder gap is an open space between the cylinder and the barrel that ranges in size from .003 in. to .013 in., depending on caliber and model. The projectile will then enter the forcing cone of the barrel before engaging the rifling of the bore. The projectile is then forced from the bore, out of the muzzle (Figure 6d).

- **Unlocking** – The unlocking step in the cycle of operations opens the chamber after firing. This can happen either manually or automatically depending on the action being employed. Also, depending on the action used, this may be an actual physical unlocking or just an "opening" of the chamber.

Physically unlocking the chamber involves the bolt, breech, or slide moving out of alignment from the barrel/barrel extension's locking surfaces. When chamber pressure has dropped to a safe level, the action may automatically begin to cycle or may be manually cycled. As the action moves, camming surfaces or linkage will move the locking surfaces of the barrel and bolt/breechblock/slide away from each other, allowing the action to continue to travel through its stroke. With revolvers, after the cartridge has fired and the hammer is completely de-cocked, the cylinder stop will move out of the notch in the cylinder and unlock the cylinder once again after the hammer is re-cocked or the trigger begins to move on a double-action revolver.

Blowback actions that do not physically lock the chamber (which are often semi-automatic), unlock in a much simpler way. Once the chamber pressure has dropped to a safe level and the cartridge case has contracted, energy created by the fired cartridge will overcome the inertia of the bolt/breechblock/slide and begin to push it rearward, opening the chamber. This type of action is typically reserved for low power pistol and rimfire cartridges.

- **Extracting** – The extracting step in the cycle of operations removes the spent cartridge case from the chamber. A part called the *extractor*, which features a small hook on its inside face, is used to grab the rim of the cartridge case. As the action cycles, either manually or automatically, and the bolt/breechblock/slide begins to move to the rear of the action, the extractor will pull on the cartridge and begin to remove it from the chamber. As the action continues to move rearward, the extractor will continue to pull against the rim of the case until the extractor has completely removed the case from the chamber. Once the case is fully extracted, it can now be ejected. With revolvers, the extracting and ejecting steps are the same.

- **Ejecting** – The ejecting step in the cycle of operations completely removes the spent case from the breech of the firearm. This can happen either manually or automatically depending on the type of action being employed. A part called the *ejector* is used to drive the spent case out of the breech. There are two types of ejectors: stationary and dynamic.

Figure 8: The extracting step in the cycle of operations.

Figure 9: The ejection step in the cycle of operations.

Stationary ejectors are typically fixed to the receiver of the firearm**.** As the action cycles, either manually or automatically, the extractor will pull the case into the ejector and cause it to deflect away from the ejector and out of the breech. Much of the reliability of this type of ejection is dependent on the shape and location of the ejector and the force of the action cycling.

Dynamic ejectors are typically spring-driven and live in the bolt or breech face of the firearm. As the action cycles, either manually or automatically, the ejector will place constant force against the cartridge case. Once the case has been fully extracted from the chamber, the ejector will immediately try to throw the case from the breech. The reliability of dynamic ejectors is less dependent on outside forces and, in turn, provides more consistent ejection.

Once the cycle is complete, depending on the type of action being employed, the cycle can now be repeated, either manually or automatically. A new round is either inserted manually or the action will automatically strip a new round from a feed source. The cycles will continue until the feed source is empty or the operator stops inserting new rounds or a malfunction occurs.

Types of Firearms

Now that you have a basic understanding of how most firearms operate, you can begin to differentiate the various types. There are three basic types of firearms, with a few sub categories based on features and options. The three main types of firearms are handguns, rifles, and shotguns.

Currently, almost all firearms, with the exception of breech and muzzleloading black powder guns, are regulated by the Bureau of Alcohol, Tobacco, Firearms and Explosives (ATF). Although there is no national registration for firearms, the ATF provides definitions and criteria that are used to classify firearm types for regulation by individual states. The ATF does regulate the minimum age for purchasing and possessing certain firearm types. The National Firearms Act (NFA) Branch of the ATF places further regulation and restriction on special types of firearms that are not easily attainable by the civilian market.

- **Handgun** – The term "handgun" is a generic term for any firearm meant to be discharged with only one hand, with no other support. Handguns can be classified by barrel length and other features, specifically the lack of certain features. There are two types of handguns: pistols and revolvers. The two types are defined by their characteristics defined below.

  The term "Pistol"[1] *means a weapon originally designed, made, and intended to fire a projectile (bullet) from one or more barrels when held in one hand, and having:*

- *a chamber(s) as an integral part(s) of, or permanently aligned with, the bore(s);*
- *and a short stock designed to be gripped by one hand at an angle to and extending below the line of the bore(s).*

[1] 18 U.S.C., § 921(A)(29) and 27 CFR § 478.11

Figure 10: Various handguns, rifles, shotguns, and NFA items.

Revolvers are defined by the ATF in the following:

The term "Revolver"[2] means a projectile weapon of the pistol type, having a breech loading chambered cylinder so arranged that the cocking of the hammer or movement of the trigger rotates it and brings the next cartridge in line with the barrel for firing.

[2] 18 U.S.C., § 921(A)(29) and 27 CFR § 478.11

Regardless of classification, handguns will feature a rifled barrel that is less than 16 in. in length with no other provisions for support other than the standalone grip. The term pistol basically defines any handgun that is not a revolver. The main defining feature of a revolver is the cylinder. Handguns are typically reserved for small-caliber pistol cartridges from .17 to .50, but are also capable of firing much larger rifle and shotgun cartridges in larger framed guns.

Handguns are often regulated more stringently than other types of firearms because of their ability to easily conceal and transport. Most states require a special license that grants the bearer the right to carry a handgun "concealed." Handguns can only be purchased from dealers by someone who is 21 years old and in most states cannot be possessed by anyone under the age of 18 without an adult present. Also, handguns cannot be purchased outside of your state of residence without shipping the firearm between FFLs (the purchaser cannot take direct possession outside of their state of residence). *

**State and local laws may differ from federal law and place further restrictions. Always check federal, state and local laws regarding firearms.*

Figure 11: Various types of handguns.

- **Rifle** – A rifle is a type of firearm that is designed to be fired with support from both the hands and shoulder. Rifles are defined by the ATF in the following:

  The term "Rifle"[3] means a weapon designed or redesigned, made or remade, and intended to be fired from the shoulder and designed or redesigned and made or remade to use the energy of the explosive in a fixed metallic cartridge to fire only a single projectile through a rifled bore for each single pull of the trigger.

  [3] 18 U.S.C., § 921(A)(7) and 27 CFR § 478.11

  The ATF also regulates the barrel length of rifles. All rifles must use at least a 16 in. rifled barrel or face further regulation under the NFA. Rifles also must meet a 26 in. overall length (OAL) (this includes 16 in. of barrel) or face the same NFA regulations. Rifles are typically reserved for high-power rifle cartridges, but are more than capable of handling smaller pistol cartridges and larger shotgun cartridges. The minimum age to purchase and possess a rifle is 18.

Figure 12: Various types of rifles.

- **Shotgun** – A shotgun is also a type of firearm that is designed to be fired with support from both the hands and shoulder. Shotguns are defined by the ATF in the following:

  The term "Shotgun"[4] means a weapon designed or redesigned, made or remade, and intended to be fired from the shoulder, and designed or redesigned and made or remade to use the energy of the explosive in a fixed shotgun shell to fire through a smooth bore either a number of ball shot or a single projectile for each single pull of the trigger.

  [4] 18 U.S.C., § 921(A)(5) and 27 CFR § 478.11

  The two features that differentiate rifles and shotguns are the barrels and ammunition. While rifle barrels feature rifling, shotgun barrels feature a smooth bore. Shotguns also fire ammunition that utilizes multiple projectiles that do not require the spin imparted by the rifling. Shotguns are capable of firing from one to several hundred tiny projectiles with a single cartridge.

  The ATF also regulates the barrel length of shotguns. All shotguns must use at least an 18 in. smooth bore barrel or face further regulation under the NFA. Shotguns also must meet a 26 in. overall length (OAL) (this includes 18 in. of barrel) or face the same NFA regulations. Shotguns are only designed to fire shotgun cartridges. The minimum age to purchase and possess a shotgun is 18.

Figure 13: Various types of shotguns.

NFA FIREARMS

NFA firearms are guns that require special paperwork and tax to own. They are regulated more heavily than standard firearms by a special branch of the ATF. The NFA branch enforces the **National Firearms Act of 1934** and the amendments of 1968 (Title II) and 1986. The type of firearms that are covered by the NFA include machine guns or select fire weapons, short barrel rifles and shotguns (SBR/SBS), Any Other Weapons (AOW), and silencers/suppressors. All NFA firearms are restricted to anyone under the age of 21.

- **Machine gun/Select Fire** – A machine gun or select fire weapon is a firearm that is capable of firing more than one round at a time with a single trigger pull. These firearms will continue to fire until the ammunition carrier is empty or the trigger is released (automatic/machine gun) or fires a limited amount of rounds (two to three) before the trigger must be reset. Machine guns are defined by the NFA in the following 26 U.S.C. § 5845(b):
  - Any weapon that shoots, is designed to shoot, or can be readily restored to shoot, automatically more than one shot without manual reloading, by a single function of the trigger
  - The frame or receiver of any such weapon
  - Any part designed and intended solely and exclusively or combination of parts designed and intended for use in converting a weapon into a machine gun, or
  - Any combination of parts from which a machine gun can be assembled if such parts are in the possession or under the control of a person.

There are an extremely limited number of machine guns that are available for transfer to the civilian market, which makes them very valuable. There are an estimated 170,000 transferrable machine guns in the U.S., with prices ranging from $8,000 to $100,000+. The Firearm Owners Protection Act of 1986 (FOPA), which is an amendment of the National Firearms Act of 1934, restricted the sale of newly manufactured machine guns to military, law enforcement, manufacturers, and dealers. The transferrable

Figure 14: An M16 machine gun.

Figure 15: Short barrel rifle.

guns are subject to an ATF Form 4 transfer and a $200 transfer fee (tax stamp).

- **Short Barrel Rifle/Shotgun** (SBR/SBS) – A short barrel rifle or shotgun is a firearm with a barrel length or AOL shorter than the regulated limit, which is 16 in. and 26 in. for rifles and 18 in. and 26 in. for shotguns. The NFA defines SBRs and SBSs in the following 26 U.S.C., § 5485(a):
  - § 5845(c) — The term "Rifle" means a weapon designed or redesigned, made or remade, and intended to be fired from the shoulder, and designed or redesigned and made or remade to use the energy of the explosive in a fixed metallic cartridge to fire only a single projectile through a rifled bore for each single pull of the trigger.
  - § 5845(a)(3) — The term "Firearm" means a rifle having a barrel or barrels of less than 16 in. in length;
  - § 5845(a)(4) — The term "Firearm" means a weapon made from a rifle if such weapon as modified has an overall length of less than 26 in. or a barrel or barrels of less than 16 in. in length; 26 U.S.C. Chapter 53.
  - § 5845(d) — The term "Shotgun" means a weapon designed or redesigned, made or remade, and intended to be fired from the shoulder, and designed or redesigned and made or remade to use the energy of the explosive in a fixed shotgun shell to fire through a smooth bore either a number of ball shot or a single projectile for each single pull of the trigger.
  - § 5845(a)(1) — The term "Firearm" means a shotgun having a barrel or barrels of less than 18 in. in length;
  - § 5845(a)(2) — The term "Firearm" means a weapon made from a shotgun if such weapon as modified has an overall length of less than 26 in. or a barrel or barrels of less than 18 in. in length.

Short barrel rifles and shotguns are not controlled by the 1986 FOPA regulations, which makes them more abundant than machine guns. In fact, current production SBRs and SBSs are transferrable to civilians through a Form 4 transfer and $200 transfer fee. SBRs and SBSs can also be legally manufactured by any civilian who is able to own firearms. Attaching a buttstock to a pistol converts it into an SBR and

requires the same paperwork and fees. Before the item can be made, an ATF Form 1 must be filed and approved and the $200 transfer fee must be paid.

- **Any Other Weapon** (AOW) – Any Other Weapons (AOW) are firearms that do not meet the criteria of standard firearms. AOWs include items that were never designed as firearms but were modified to fire metallic cartridges. AOWs are defined by the NFA in the following 26 U.S.C. § 5845(E):
  - Any weapon or device capable of being concealed on the person from which a shot can be discharged through the energy of an explosive;
  - A pistol or revolver having a barrel with a smooth bore designed or redesigned to fire a fixed shotgun shell;
  - Weapons with combination shotgun and rifle barrels 12 in. or more, less than 18 in. in length, from which only a single discharge can be made from either barrel without manual reloading; and
  - Any such weapon which may be readily restored to fire.
  - Such term shall not include a pistol or a revolver having a rifled bore, or rifled bores, or weapons designed, made, or intended to be fired from the shoulder and not capable of firing fixed ammunition.

AOWs include weapons like smoothbore pistols that fire shotgun cartridges, specific lengths of combination and drilling guns, and weapons such as pen/knife/cane guns. Placing a vertical grip on a pistol converts it into an AOW and requires further NFA regulation. Like machine guns and SBRs/SBSs, AOWs are transferred with an ATF Form 4, or can be manufactured using Form 1. The transfer fee is much less at $5 instead of $200.

Figure 16: An AOW.

- **Silencer/Suppressor** – Silencers/suppressors are devices that reduce the report of the cartridge's discharge. Silencer is a generic term for a suppressor, as it does not completely silence the sound of the cartridge being fired. Suppressors are defined by the NFA in the following 26 U.S.C. § 5845(a)(7):
  - For the purposes of the National Firearms Act the term Silencer is defined in 18 U.S.C. § 921(a)(24).
  - The term "Firearm Silencer" or "Firearm Muffler" means any device for silencing, muffling, or diminishing the report of a portable firearm, including any combination of parts, designed or redesigned, and intended for the use in assembling or fabricating a firearm silencer or firearm muffler, any part intended only for use in such assembly or fabrication.

Any device that reduces the report of a firearm one decibel (dB) for one shot is considered a suppressor. Most suppressors reduce the sound of the cartridge's discharge 20 – 30dB and bring the noise to a safe hearing level (typically below

Figure 17: Various suppressors.

130dB). Most suppressors are capable of being easily attached and removed from their host firearm, but some are permanently attached to their respective firearm, making the whole firearm a suppressor and, in turn, regulated by the NFA. Suppressors can be permanently attached to rifles and shotguns to make the barrel long enough to meet non-NFA requirements and forego the extra transfer fee (the rifle/shotgun is not considered an SBR/SBS because the suppressor makes the barrel legal length). Suppressors are transferred using Form 4 and can be manufactured by individuals using Form 1. Suppressors are subject to a $200 transfer fee.

BULLPUPS, CARBINES, AND SUBMACHINE GUNS

There are a few other types of firearms that are not specifically regulated by the ATF (because they fall under categories that are regulated). Bullpups and carbines are technically rifles, but meet the absolute minimum size requirements. Submachine guns are technically machine guns, but are chambered in pistol calibers.

A carbine is a shortened version of a rifle. The carbine was designed to be a more compact, maneuverable version of an existing service firearm that still used rifle caliber cartridges. The carbine design utilizes shorter barrels than their rifle counterparts and replaces fixed stocks with adjustable collapsing and folding units. For example, an M4 rifle has a 14.5 in. barrel with a collapsible buttstock and is the carbine version of the M16A1 rifle with a 20 in. barrel. Most carbines fit within the 16 in. barrel and 26 in. OAL requirements for rifles but may also be slightly short and classified as SBRs.

The term "carbine" is also used to describe the armed forces M1 (semi-automatic) and M2 (select fire) rifles. The M1 is a short, light, limited-range rifle chambered in .30 Carbine. The carbine concept is believed to be the brainchild of David Marshall "Carbine" Williams. He built his first prototype in the 1930s in a prison machine shop from scrap material and car parts.

The bullpup is a type of firearm design in which both the action and magazine are located behind the grip and trigger. The bullpup was

designed to be even more compact than the carbine and much easier to maneuver in compact spaces. Placing the firing controls further forward allows the action to double as the stock. This configuration allows the rifle to be much shorter without sacrificing barrel length. The bullpup is also much lighter than a rifle with the same barrel length. Its compact, lightweight design and balanced handling also help to mitigate some felt recoil and reduce operator fatigue. The bullpup still fits within the 16 in. barrel and 26 in. OAL for rifles.

The submachine gun (SMG) is categorized as a type of machine gun. Unlike other machine guns, which use rifle caliber cartridges and fixed stocks and 14.5 in. and longer barrels, the SMG is chambered for pistol caliber rounds, uses collapsible and folding stocks, and barrel lengths around 8 in. The SMG was designed to be easily concealable and compact enough for small spaces like helicopters, tanks, and other vehicles. The use of a smaller cartridge also makes the firearm more controllable under burst and automatic fire. The submachine gun is used primarily by military and police for close quarter battle (CQB) roles where over-penetration from rifle rounds is a concern.

Figure 18: A bullpup (top), carbine (left), and SMG (right).

Chapter 3: Manual Actions and Operating Types

Action and Operation Types

Now that you have a basic understanding of the various firearm types, it is time to learn about the different actions and operations that drive these simple machines. Depending on the action type, the cycle of operations is either performed manually or automatically. Further classification comes from the way in which the action operates. Some actions, especially semi-automatic action types, operate in many different ways.

The action types can also be classified by the number of rounds that can be fired in succession. The two types are single-shot and repeating. Single-shot firearms are only capable of firing one round before needing to be reloaded and do not feature any provision to store extra rounds. Repeating firearms are capable of firing multiple rounds that are stored either internally in the firearm's action itself, or in a removable storage device that can be quickly replaced. Many of the different action types are employed with both single-shot and repeating firearms. All of the actions that are discussed are designed to be used with modern metallic cartridges and smokeless propellant.

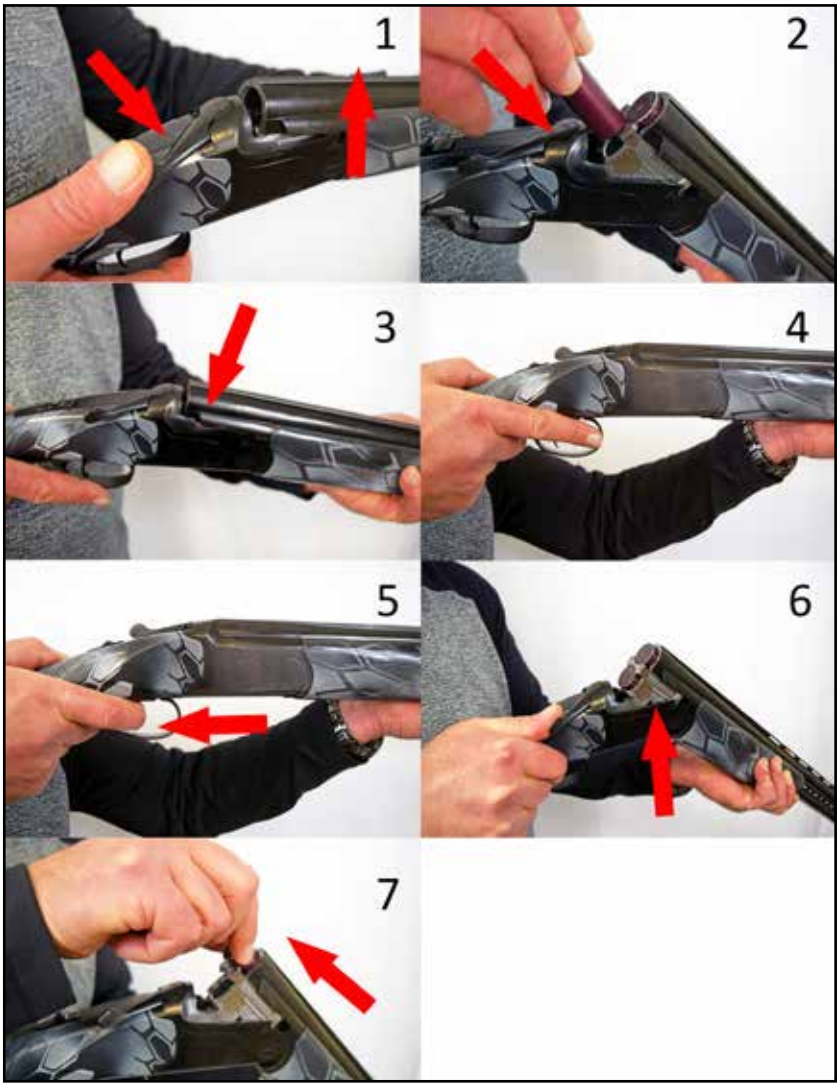


Figure 1: Break-action cycle of operations.

MANUAL ACTIONS

Manual actions rely on the operator to perform many of the steps of the cycle of operations. This means the operator must physically manipulate part of the firearm's action to feed, chamber, lock, cock, fire, unlock, extract, and eject the cartridge. There are many different types of manual actions with several different types of operation.

BREAK-ACTION

Break-action firearms are so named because the action will "break open" to reveal the breech. The barrel(s) is/are hinged to the receiver and allow them to rotate to open and close the action. The break-style action is used with pistols, rifles, and shotguns. The break-action system is a manual action that must be manipulated by the operator in order to complete the cycle of operations (Figure 1). With an empty and locked action, the cycle of operations for a break-action firearm is as follows:

- A lever on the top rear of the receiver (top lever) is manipulated to unlock the action and allow the barrel(s) to rotate around the hinge pin, exposing the breech and chamber(s). (1)
- Rounds are fed and chambered by hand into the exposed chamber(s). (2)
- The operator closes the breech and locks the action by manually rotating the barrels around the hinge pin until the locking lug or crosspin engages. (3)
- Depending on the firearm, the hammer(s) or strikers(s) must be manually cocked or are cocked automatically when the action is opened or closed. (4)
- The trigger(s) is/are pressed, releasing the hammer(s) or striker(s) and discharging the cartridge(s). (5)
- The top lever is manipulated once again, unlocking the breech and allowing the barrel(s) to rotate around the hinge pin, exposing the chambers. (6)
- Depending on the firearm, the empty cartridge case(s) is/are either extracted and ejected manually, when the operator physically removes it from the chamber,

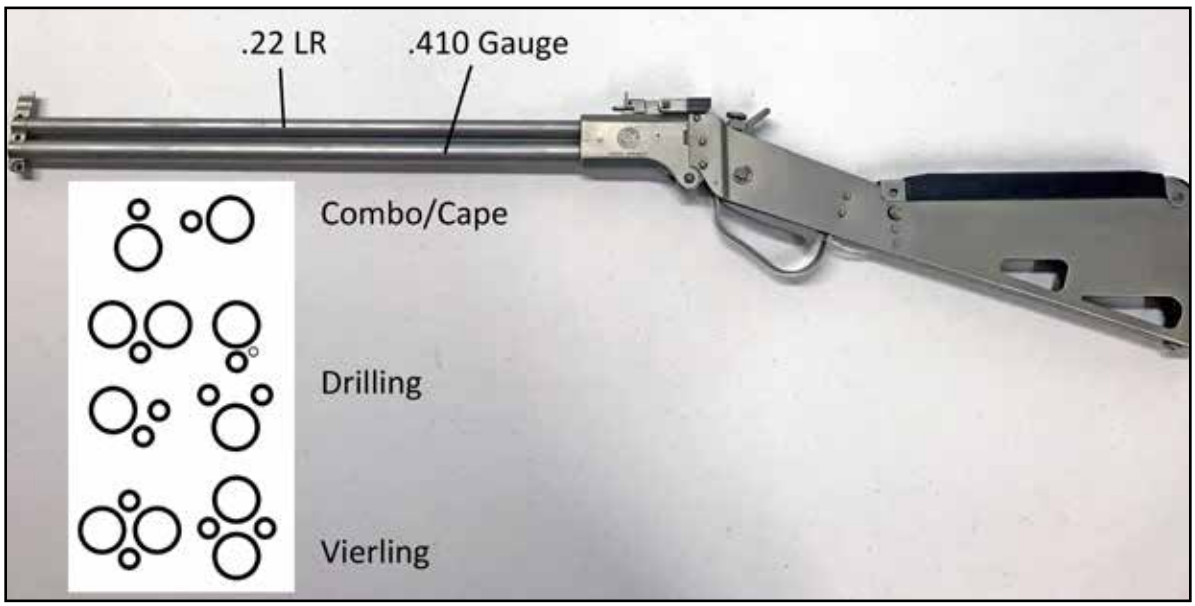


Figure 2: Combination gun barrel layout.

Figure 3: Break-action shotgun.

or automatically when the action opens and a spring-loaded extractor/ejector pushes the case out of the breech. (7)

- The action is now open, the chamber is exposed, and the firearm is ready to be loaded once again.

The break-style action is employed by both single-shot and repeating firearms. Single-shot break-action firearms feature only one barrel that must be reloaded after every shot. Repeating break-action firearms feature multiple barrels (two to four), which can vary in caliber. The most popular repeating break-action firearms are double-barrel shotguns. Double-barrel break-action shotguns come in two different configurations: side-by-side or over-under. The names come from the way the barrels are arranged.

Side-by-side shotguns feature two barrels that are arranged horizontally or next to each other. Over-under shotguns feature two barrels that are arranged vertically or "stacked" on top of one another. Both barrels on side-by-side and over-under shotguns are always the same caliber and chamber size, but the chokes may differ. The barrels are not perfectly parallel either. Each barrel is slightly canted so that both barrels will have roughly the same point of impact at a given distance, usually within 3 in. to 4 in. of each other at 40 yards.

Combination guns feature two to four barrels, arranged in various ways. The difference between combination guns and double-barrel shotguns is that combo guns feature barrels that are different types and calibers. A combination gun may use one barrel that is chambered for a shotgun round with a smooth bore, another barrel that is chambered for a rifle round with a rifled barrel, and another barrel that is chambered for a pistol or rimfire round with a rifled bore. Barrel arrangement can vary greatly based on the number of barrels and the caliber and type of each barrel. Two-barreled combo guns with a side-by-side arrangement are referred to as cape

guns, three-barrel combo guns are referred to as Drilling (German for triplet), and four-barrel guns are referred to as Vierling (German for quadruplet).

The break-action is often constrained to rimmed cartridge chamberings because of extractor and cartridge interactions. Break-action firearms use a "flat" extractor to push against the rim of the cartridge in order to extract and eject it (other firearms use a hooked extractor to pull the case from the chamber). This allows the break-style action the ability to extract multiple cartridge cases of different calibers at the same time.

Figure 4: Rolling-block cycle of operations.

One drawback of the break-action design is its inability to handle high pressure cartridges. The breech locking mechanism often consists of a single locking lug that is only capable of safely containing the pressure from shotgun and low pressure pistol and rifle rounds. Some newer designs have introduced additional locking lugs or a crossbolt to help distribute some of the load generated from higher power cartridges.

The break-style action is one of the oldest breechloading designs that is still in use today and is popular with hunters and the sporting community. The break-action design requires a very compact receiver, which allows the use of longer barrels and creates an overall length that can still be easily maneuvered. The versatility of combo guns allows the user to hunt various types of game without the need for multiple firearms. Over-under shotguns dominate trap and skeet competitions and are very popular for hunting fowl. The break-action is also known as the top-break or break-barrel action.

ROLLING-BLOCK ACTION

The rolling-block action gets its name from the fact that the breechblock will "roll" in and out of battery. The breechblock, which features one side that is shaped like an arc, rotates around a pin and exposes the chamber when opened and completes the chamber when closed. The rolling-block action is used with pistols, rifles, and shotguns. The rolling-block action system is a manual action that must be manipulated by the operator in order to complete the cycle of operations. With an empty and locked action,

the cycle of operations for a rolling-block firearm is as follows:

- The hammer is manipulated into the "cocked" position, freeing the breechblock.
- The breechblock can now be manipulated to the rear, rotating around its pivot pin, unlocking the breech and revealing the chamber.
- Cartridges are fed into the chamber by hand until they are nearly seated.
- The breechblock can now be rotated forward, securing the cartridge in the chamber.
- The trigger is pressed, releasing the hammer. Before the hammer strikes the firing pin, it enters a slot in the breechblock. At the same time, a step on the hammer wedges itself under the breechblock, fully locking the chamber. The hammer will continue to fall, firing the round.
- The hammer is manipulated once again, freeing the breechblock and allowing the chamber to unlock.
- The breechblock is manipulated to the rear once again, rotating around its pivot pin and activating the extractor/ejector. The empty case is expelled from the breech.
- The action is now open, the chamber is exposed and the firearm is ready to be loaded once again.

The rolling-block action was one of the most successful action types of the 19th century and found heavy use in both military and civilian applications. Remington Arms Company, LLC was the first to use the rolling-block action with their model 1865 pistol, which saw use with the U.S. Navy. Remington's M1867 solidified the company's future, producing nearly 1.5 million rolling-block firearms for over 70 years. Remington had so much success with the rolling-block design that the rolling-block action is often referred to as the "Remington action."

The rolling-block design is considered out-of-date by modern military standards. The design is strictly a single-shot action and was so popular because of its strength and simplicity: the action requires very few moving parts, which are very robust and not susceptible to malfunctions from dirt and debris.

Drawbacks to the rolling-block design include its inability to fire repeatedly and the weak point around the pivot pin. Although the rolling-block action was extremely popular during

Figure 5: Rolling-block rifle.

Figure 6: Falling-block cycle of operations.

its time, the advent of the bolt-action and its ability to fire multiple rounds before reloading made the rolling-block obsolete. The rolling-block action still sees use today as a collector's and enthusiast's item and is still manufactured in small numbers as a reproduction piece.

FALLING-BLOCK ACTION

The falling-block action is so named because of the fact that the breechblock will "rise and fall," opening and closing the action. When the action is manipulated through an external lever, the breechblock will move up and down within vertical grooves in the receiver. The falling-block action is used with pistols, rifles, and shotguns and its system is a manual action that must be manipulated by the operator in order to complete the cycle of operations. With an empty and locked action, the cycle of operations for a falling-block firearm is as follows:

- A lever is manipulated down and forward while linkage pulls the breechblock down. The chamber is now unlocked and exposed.
- A cartridge is fed by hand and fully seated.
- The lever is manipulated back and up, pushing the breechblock upward and locking the chamber.
- The hammer is set to the cocked position.
- The trigger is pressed, releasing the hammer and discharging the cartridge.
- The lever is manipulated once again, unlocking and opening the chamber.
- The empty cartridge case is extracted from the chamber and removed from the breech by hand.

- The action is now open, the chamber is exposed, and the firearm is ready to be loaded once again.

The falling-block action is touted as being one of the strongest firearms actions available. The action is so strong that it is employed by heavy artillery cannons. The action gets all of its strength from the sheer size and mass of the breechblock. The receiver is also fairly stout, which adds to the strength of the action.

One of the first and most notable firearms to use the falling-block action was the Sharps rifle. The Sharps rifle and the falling-block action saw great success during the civil war, becoming a popular weapon amongst sharpshooters and snipers. The firearms that saw use during the civil war still used percussion cap technology, which was a huge advance over the muzzleloaders, match, and flintlock technologies. It wasn't until 1874 that metallic centerfire cartridges replaced percussion caps.

Despite the incredible strength the action has to offer, its major downfall is its inability to fire more than one round. Although the falling-block action was extremely popular during its time, the advent of the bolt-action and its ability to fire multiple rounds before reloading made the falling-block obsolete as a military arm. The falling-block action still sees use today as a collector's and enthusiast's item and is still manufactured in small numbers.

Similar to the falling-block action, the tilting-block action operates almost identically. The lever manipulation and cycle of operations almost mirror the falling-block, with the one difference being the movement of the breechblock. While the falling-block breechblock moves vertically, the tilting-block (Figure 8) breechblock pivots similarly to the rolling-block action. When the lever is manipulated down and forward, linkage pulls the front of the breechblock down as it rotates around its pivot pin. When the lever is pulled to the rear and up, the front of the breechblock will pivot up, sealing the chamber and locking the breech.

BOLT-ACTION

The bolt-style action is so named because it uses a cylindrical tube called a bolt rather than a breechblock. The bolt is manipulated in various ways to complete the various steps in the cycle of operations. The bolt-style action is used with pistols, rifles, and shotguns. The bolt-style action system (Figure 9) is a manual action that must be manipulated by the operator in order to complete the cycle of operations. With an empty and locked action, the cycle of operations for a bolt-action firearm is as follows:

- A handle that is attached to the bolt is manipulated to unlock the breech and open the chamber. Depending on the specific model, the bolt may need to be rotated and pulled to the rear of the receiver or

Figure 7: Falling-block rifle.

Figure 8: Tilting-block rifle.

pulled straight to the rear of the receiver. The chamber is now open and exposed. Also, depending on model, the striker is set to the cocked position. (1)

- Depending on the specific model, feeding will happen one of two different ways. With single-shot bolt-action firearms, a cartridge must be fed by hand into the breech. Repeating bolt-action firearms are either fed by an internal or removable box magazine. The bolt is pushed forward, driving the round into the chamber. Also, depending on the model, the actual act of feeding may happen one of two ways: controlled or push. With a controlled feed system, when the round is stripped from the magazine, the rim of the cartridge slides under the claw of the extractor and rides up the bolt face. With a push feed system, the extractor does not grab the rim of the cartridge until it is fully seated and the chamber is locked. When the bolt moves forward and strips a round from the magazine, the face of the bolt and extractor pushes the round into the chamber until it is fully seated. When the round bottoms out in the chamber, the extractor claw will jump over the rim of the cartridge. (2)
- The bolt is driven fully forward, completely seating the cartridge. Depending on the specific model, the chamber may be fully locked or the bolt may still need to be rotated to completely lock the chamber. Also, depending on the model, the striker may be set to the cocked position. (3)
- The trigger is pressed, releasing the striker and igniting the cartridge's primer. (4)
- The bolt is manipulated once again, unlocking the chamber. (5)
- As the bolt begins to travel rearward the extractor begins to pull the cartridge case from the chamber. (6)
- Depending on the specific model, the ejector may be part of the bolt head itself or separate as part of the receiver or action. Some models feature built-in, plunger-style ejectors, which are powered by a spring and place constant force against the bottom edge of the cartridge case. Once the empty case has cleared the ejection port, the ejector will force it from the breech. Other models feature ejectors that are integral to the receiver or a separate part of the action. Once the bolt has reached the end of its stroke and

cleared the ejection port, the case will contact the ejector and pivot out of the breech. (7)

- The action is now open, the chamber is exposed, and the firearm is ready to be loaded once again.

There are several distinctive types of bolt-action systems that are considered standards. Those actions consist of the Mauser (M 98), the Lee Enfield, the Mosin-Nagant, and the Straight-pull. Regardless of the action style, the cycle of operations is basically the same, with the only difference being the movement of the bolt and

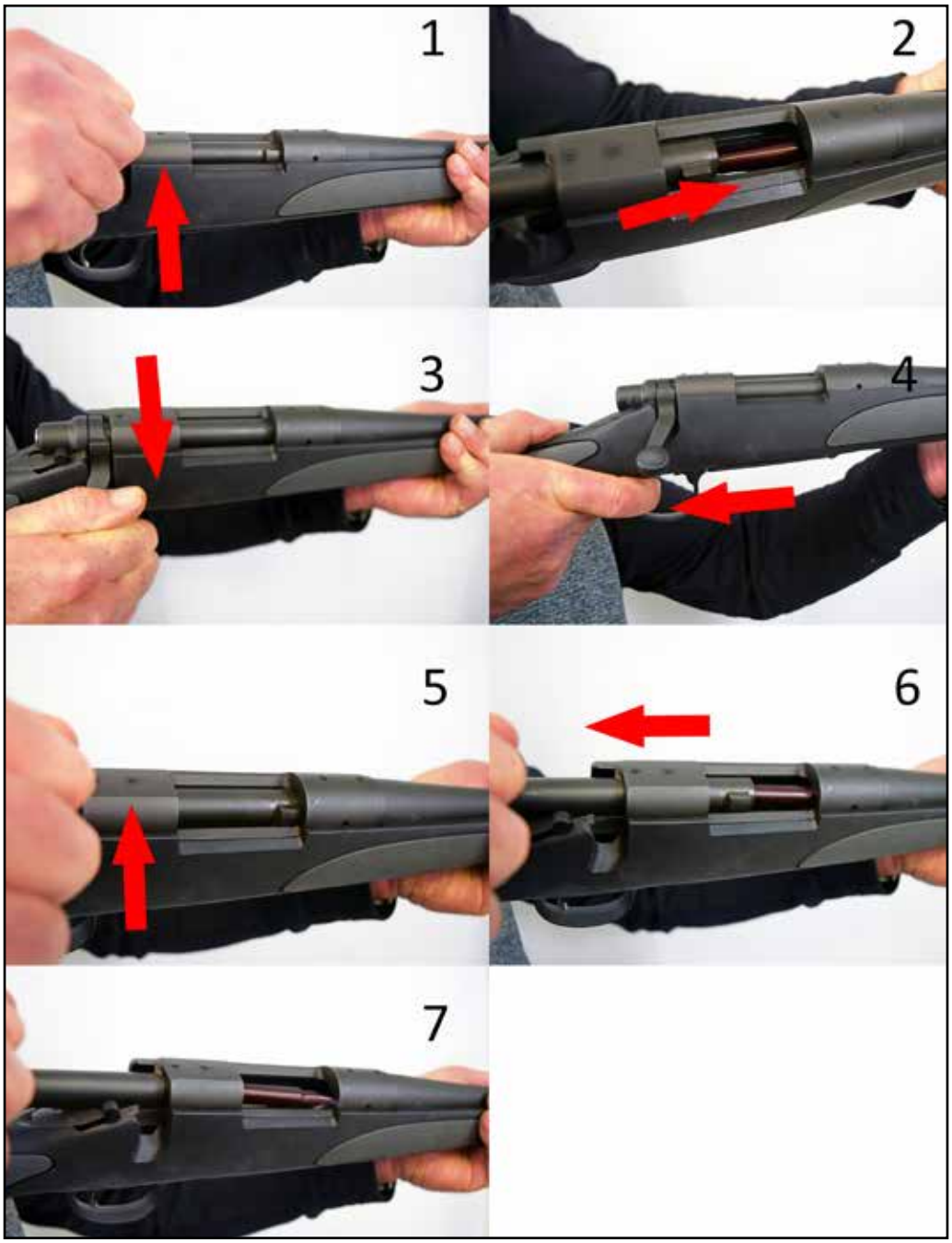


Figure 9: Bolt-action cycle of operations.

when the striker is cocked (on open or closed). The following are the differences between the action styles:

- **Mauser** – The Mauser-style action is one of the most well-known and used bolt-action systems in the world. The Mauser M 98 was introduced in 1898 and saw use with the Germans during WWI and WWII. The Mauser action is a cock-on-open system that uses a one-piece bolt and bolt head that rotates with the body as the breech is locked and unlocked. When the bolt handle is lifted up to unlock the chamber, the striker is set in the cocked position. The Mauser-style action has proven itself to be much stronger than the Lee-Enfield action because it uses two large lugs near the bolt head and an extra, redundant lug near the handle. The Mauser-style action is capable of handling great load, like the high pressure that is generated by magnum rifle cartridges.

  The Mauser-style action uses a "controlled feed" feeding system that differs from other action style's "push" feed system. The Mauser action employs a specialized extractor that holds the new cartridge centered on the bolt face the moment it is stripped from the magazine (five-round fixed). The controlled feed system facilitates a very reliable feeding step in the cycle of operations. The Mauser-style action also uses an ejector that is separate from the bolt. The ejector on the Mauser is mounted to the receiver and is spring-loaded. There is a slot cut into the side and face of the bolt that provides clearance for the ejector. When the bolt moves rearward, the ejector is compressed within the groove until it reaches the bolt face and begins to expand outward, contacting the edge of the case head and kicking the empty cartridge from the breech.

  The Mauser-style action has been employed by many different models from various manufacturers. Two of the most notable firearms are the Springfield Armory® M1903 and the Winchester® Model 70. Both firearms use the Mauser's cock-on-open, solid rotating bolt design.

- **Lee-Enfield** – Like the Mauser, the Lee-Enfield also saw heavy use during both world wars, but was fielded by the British army and with a very different operation. The Lee-Enfield employs a cock-on-close design and a two-piece bolt. Unlike the Mauser, which uses a solid one-piece body/bolt, the Lee-Enfield bolt body and head move separately from each other. When the Lee-Enfield system

Figure 10: A Mauser-style action.

Figure 11: A Lee-Enfield-style action.

is unlocked, the bolt head remains stationary while the bolt body rotates and both pieces move rearward to expose the chamber and breech. When the bolt is pushed forward, the striker is set to the cocked position.

The feed system is also slightly different than the Mauser. The Enfield uses a hybrid push/controlled feed system that makes it more versatile to load. Like the Mauser, the Enfield employs a controlled feed system when feeding from the magazine (10-round fixed), and a push feed system when single loading by hand. The Enfield also uses a receiver-mounted ejector similar to the Mauser.

- **Mosin-Nagant** – The Mosin-Nagant (Figure 12) was another hard-use military rifle that was employed by the Russians during WWI and II. The Mosin-Nagant employs a cock-on-open system and a two-piece bolt/body. Unlike the Enfield two-piece bolt, the Mosin's bolt head rotates with the body when locking and unlocking the chamber. The Mosin bolt head also uses two forward lugs like the Mauser. The Mosin utilizes the push feed system and feeds from a five-round fixed magazine. Like its counterparts, the Mosin also uses a spring-loaded, receiver-mounted ejector.

- **Straight-pull** – The straight-pull action (Figure 13) varies greatly from the other styles of bolt-action firearms. The three previous actions require the bolt handle to be rotated and pulled to open and close the action, while the straight-pull only requires the bolt handle to be pulled to the rear of the receiver to unlock and open the action and pushed forward to close and lock it. The actual locking of the chamber happens one of two ways: bearing lock and rotating bolt.

  The bearing lock system utilizes spring-loaded ball bearings, which live inside the bolt and lock into recesses in the receiver. The design of the system does not hold up under the pressure generated by high power rifle rounds, so the bearing lock system is restricted to rimfire and small-caliber pistol cartridges. The rotating bolt system is better suited for high power and magnum cartridges.

  Straight-pull actions utilize both cock-on-open and cock-on-close systems, depending on the specific model. Also,

Figure 12: A Mosin-Nagant-style action.

they may use both controlled and push feeding systems. Straight-pull actions will also typically use plunger ejectors that are housed in the bolt head. The rotating bolt straight-pull action is the precursor to the rotating bolt semi-automatic action.

The incredible versatility of the bolt-action system has withstood the rigors of battle and the test of time. The bolt-action is still in use to this very day, with different models being used by militaries, hunters, competitors, and enthusiasts around the world. Advances in technology, metallurgy, materials, and ballistics will continue to push the bolt-action rifle's life far into the future.

LEVER-ACTION

The lever-action gets its name from the fact that the action is controlled by a lever. When the lever is manipulated, linkage will cause the

Figure 13: A straight-pull action.

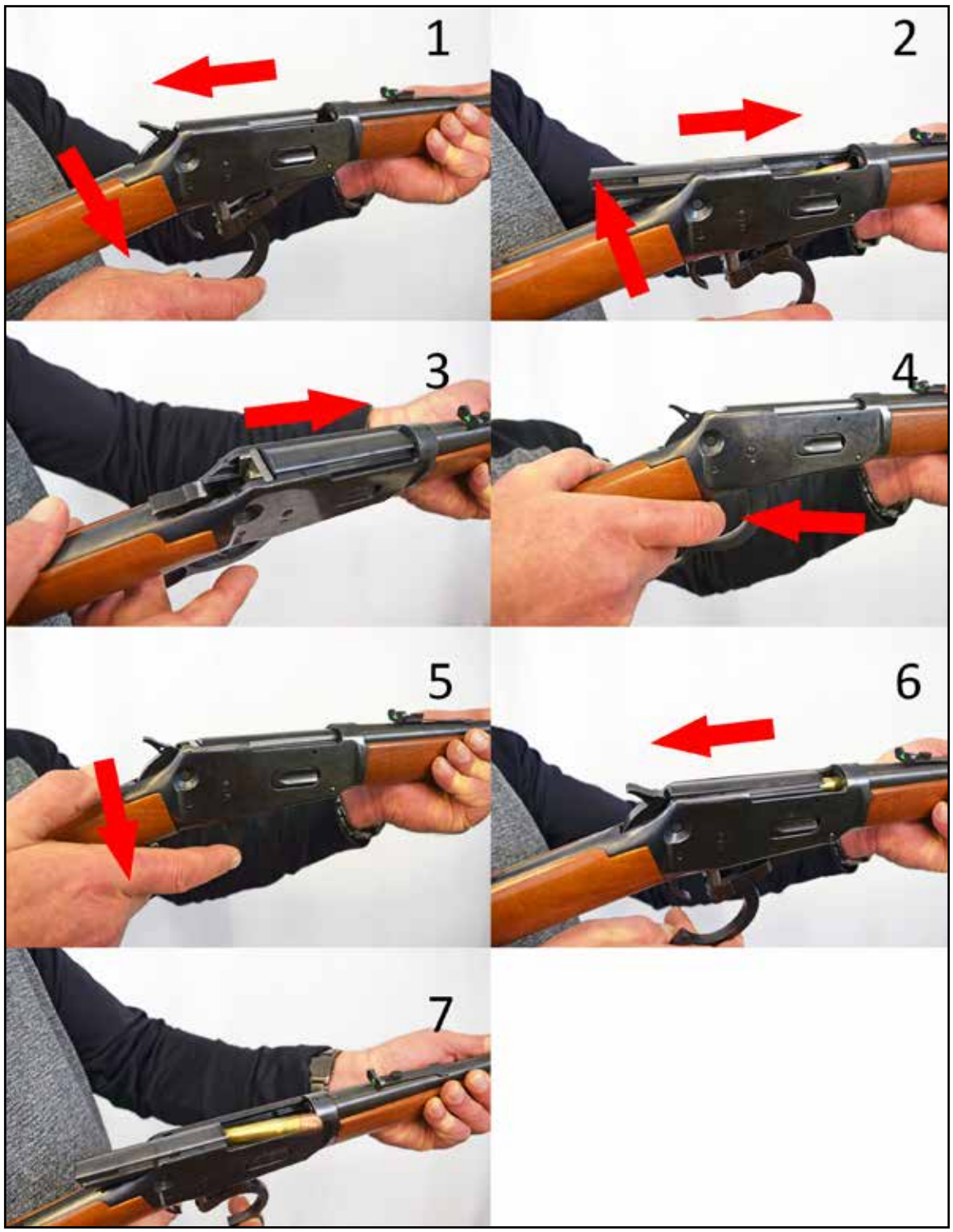


Figure 14: Lever-action cycle of operations.

bolt to travel horizontally, unlocking and locking the chamber. The lever-style action is used with pistols, rifles, and shotguns. The lever-style action system is a manual action that must be manipulated by the operator in order to complete the cycle of operations. With an empty and locked action, the cycle of operations for a lever-action firearm is as follows:

- The lever is manipulated down and forward. Linkage between the lever and bolt pushes or pulls the bolt backward, unlocking the chamber and exposing the breech. The hammer is also set to the cocked position. (1)
- The rearward travel of the bolt trips a cartridge stop/release that feeds a round from the magazine onto the lifter/elevator. (2)
- The lever is manipulated once again, back and upward, driving the bolt forward and the lifter/elevator up simultaneously. The bolt will drive the round into the chamber. When the lever bottoms out, the round will be fully seated and the chamber will be locked. (3)
- The trigger is pressed, releasing the hammer, which strikes the firing pin and discharges the cartridge. (4)
- The lever is manipulated once again, down and forward, pulling or pushing the bolt to the rear and unlocking the chamber. (5)
- On its rearward travel, the extractor (which is attached to the bolt) will pull the empty cartridge case from the chamber. (6)
- Depending on the specific model, the ejector may be fixed to the receiver or reside inside the bolt head, like the plunger style. When the bolt reaches the rear of its stroke, the round will be ejected from the breech. (7)
- The action is now open, the chamber is exposed, and the firearm is ready to be loaded once again.

The lever-action design was the natural step in evolution from single-shot to repeater. The

Figure 15: Lever-action rifle.

groundwork was already established with the falling-block action and its lever operation. The major differences of the lever-action are the use of a bolt instead of a breechblock and the addition of a feed source. Depending on the specific model, the feed source may be either a tubular, rotary, or removable box magazine. The first firearm to use the lever-action system utilized a tubular, seven-round magazine that resides in the stock of the rifle. Later models use a tubular magazine that is mounted below the barrel.

The lever-action system has seen continuous use for over 140 years with little change to the original design. The lever-action found great success as a service weapon during the Civil War and is now very popular with hunters and ranchers. The lever-action system earned some of its popularity from the action's inherent ergonomics and the fact that the action is mostly ambidextrous. Both right- and left-hand dominant shooters can easily pick up a lever gun and naturally cycle the action. The rate of fire and magazine capacity has guaranteed the lever-action system will continue to see use for years to come.

Some drawbacks of the lever-action system include limited cartridge selection and human error. The arrangement of the cartridges inside of a tubular magazine creates inherent dangers with some bullet types. Because the rounds are arranged base to tip, there is a chance that recoil could cause the tip of a pointed "spitzer" bullet to ignite the primer of the cartridge ahead of it. This means lever-actions are limited to ball and soft point bullets to prevent accidental ignition. The lever-action system is also prone to jamming when the cycling procedure is not smooth or complete. Failing to complete the full travel of the lever and bolt results in a condition known as "short stroking." Short stroking can lead to all kinds of malfunctions from feeding to ejecting. Both issues can be easily remedied by using the correct type of ammunition and practicing the proper lever stroke.

PUMP-/SLIDE-ACTION

The pump- or slide-style action gets its name from the use of a forend that must be pumped or slid to perform the steps of the cycle of operations. When the forend is moved back and forth (parallel to the barrel), linkage (action bar) will move the bolt inside of the receiver, unlocking and locking the action. The pump-style action is used with pistols, rifles, and shotguns. The pump-style action system (Figure 16) is a manual action that must be manipulated by the operator in order to complete the cycle of operations. With an empty and locked action, the cycle of operations for a pump-action firearm is as follows:

- The forend is slid backward while the action bar pushes the bolt back, unlocking and opening the chamber. The rearward movement of the bolt sets the hammer to the cocked position. (1)
- Depending on the specific model, the rearward movement of the bolt and action bar may trip a cartridge stop that feeds one round into the breech and onto the lifter/elevator. (2)
- Depending on the model, on the forward stroke the bolt may strip a round from a magazine or feed the round on the lifter into the chamber. (3)
- When the forend reaches the end of its stroke, the round will be fully seated and the chamber will be locked. The chamber may lock in various ways. Some models use a solid bolt body with a spring-loaded lug (bolt lock) that will compress when the bolt is out of battery and expand into a slot in the receiver when the bolt is locked. (4)
- The trigger is pressed, releasing the hammer and discharging the cartridge. (5)

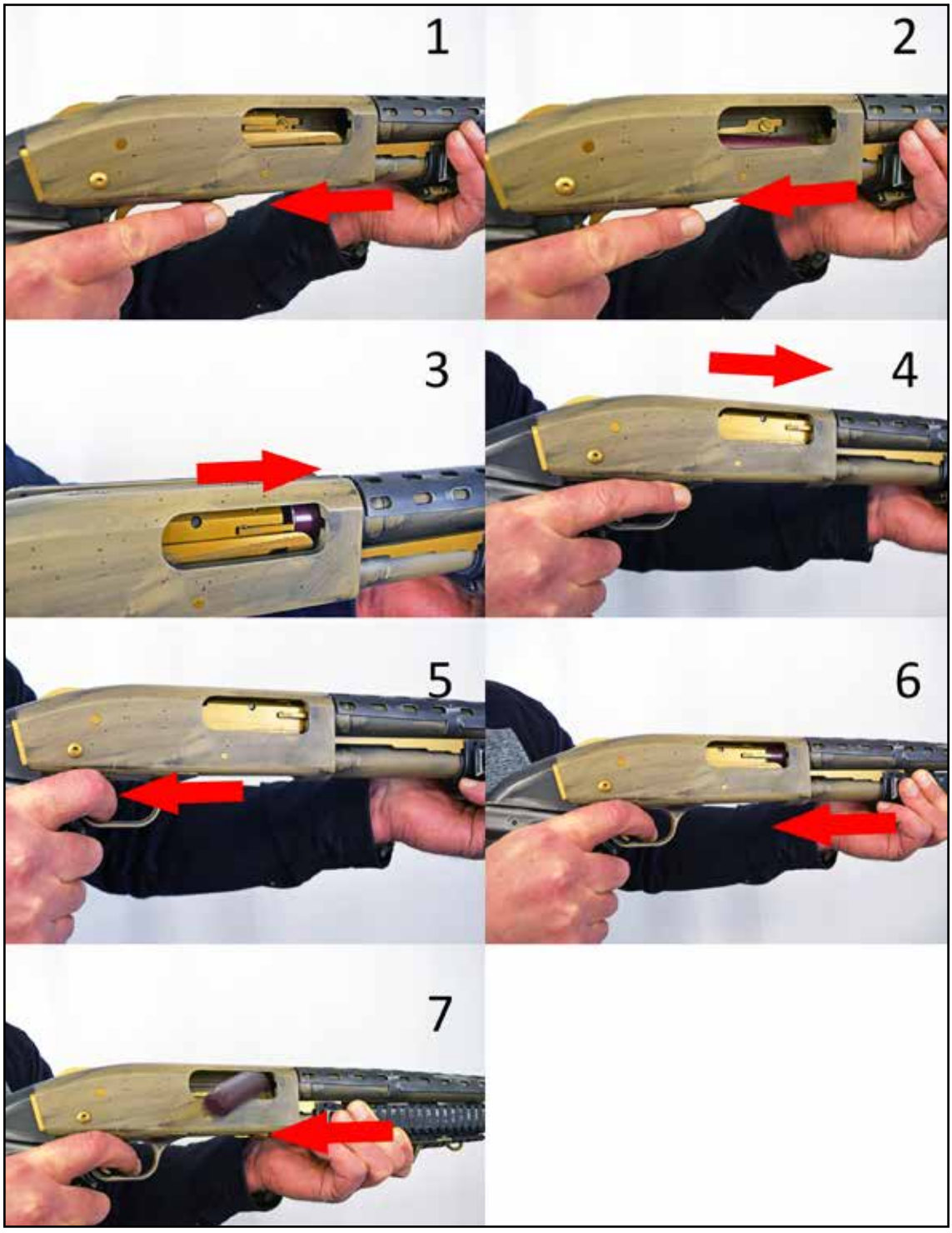


Figure 16: Pump-action cycle of operations.

- The forend is manipulated to the rear once again, unlocking the chamber. The bolt will continue to move backward, while the extractor pulls the empty cartridge case from the chamber. (6)
- When the bolt reaches the rear of its stroke, a receiver-mounted ejector will kick the round out of the breech. (7)
- The action is now open, the chamber is exposed, and the firearm is ready to be loaded once again.

Although the pump-action system is used with various rifles and pistols, the pump-action is synonymous with the pump-action shotgun, particularly ones chambered in 12-gauge. The 12- and 20-gauge shotguns have found tremendous success in every facet of the firearms community. The pump-action shotgun is as equally suited for use on the battlefield as it is for hunting, competition, or even just plinking.

The versatility of ammunition is what makes the pump-action shotgun more than capable of filling many roles. By simply changing ammo, you can equip a pump-action shotgun for big game or foul, sporting clays, home defense, and non-lethal bean bags and rubber bullets. The pump-action is simple and simple to cycle quickly, allowing for a high rate of fire. Some older models will allow you to cycle the action while holding the trigger back, essentially creating a "slam fire" situation.

Although the pump-action is capable of high rates of fire, it is limited by capacity. The most common feed source for pump-action firearms is the under-barrel tubular magazine. Because the rounds are arranged tip to base, you are limited by the length of the tube. Most 24 in. barreled pump-action shotguns can only hold six to seven rounds and most have limiters that restrict them to three (two in the magazine and one in the chamber). Pump-action firearms are also susceptible to human error. Like the lever-action, if the pump-action is short-stroked, it can create many different malfunctions.

The pump-style action is over 160 years old, with no sign of going obsolete. The pump-action shotgun has become a staple firearm for all. Almost every military or police force around the world employs at least one pump-action shotgun. No other firearm is as versatile as a pump-action shotgun, which can fill almost every role a firearm can expect to see.

Figure 17: Pump-action shotgun.

REVOLVER ACTION

The revolver-style action is so named because of the use of a revolving cylinder, which contains several chambers. The revolver-style action is very unique in design and operation. When the action is manipulated, a rotating cylinder aligns various chambers with the barrel in preparation for firing. The revolver-style action is used with pistols, rifles, and shotguns. The revolver-style action system is a manual action that must be manipulated by the operator in order to complete the cycle of operations. There are two basic operation types of the revolver action: single- and double-action. With an empty and locked action, the cycle of operations for a single-action (Figure 18), revolver-style action firearm is as follows:

- The hammer must be set to a "half-cock" position, which allows the cylinder to rotate freely. This is the unlocking step in the cycle of operations. (1)
- A hinged door on the side of the revolver, called the loading gate, is swung down into the open position. With the rear of the cylinder exposed, rounds are loaded by hand, one by one, rotating the cylinder between rounds (five to eight). Once all the chambers have been loaded, the loading gate is closed. (2)
- The hammer is set to the cocked position. As the hammer is being cocked, linkage pushes a part called the hand into a part on the cylinder called the ratchet. Also, at the same time, a part called the bolt begins to rise from the frame. Before the hammer fully cocks, the hand will rotate the cylinder until the chamber is perfectly aligned with the barrel. When the barrel and cylinder are perfectly aligned, the bolt will engage the locking notch on the cylinder and lock the chamber. (3)
- The trigger is pressed, releasing the hammer and discharging the cartridge. Once the hammer has fallen, the bolt will drop and free the cylinder. (4)
- The hammer is cocked again, rotating the cylinder and aligning a fresh cartridge. (5)
- Once all the rounds have been fired, the cylinder can be unloaded. Set the hammer to the half-cock position and open the loading gate. Align the first chamber with the opening of the loading gate. (6)
- Depress the ejector rod to eject the empty case from the chamber. Rotate the cylinder and repeat the process until all the chambers have been unloaded. (7)
- The action is now open, the chamber is exposed, and the firearm is ready to be loaded once again.

With an empty and locked action, the cycle of operations for a double-action (Figure 19), revolver-style action firearm is as follows:

- The cylinder release is depressed, allowing the cylinder to swing out from the frame and expose all the chambers at the same time. (1)
- All chambers are loaded by hand and the cylinder is swung back into the frame. (2)
- One of two operations can happen:
  1. The hammer can be cocked like a single-action revolver, simultaneously turning and locking the cylinder. 2. The trigger is pressed, simultaneously cocking the hammer, rotating the cylinder and locking it before dropping the hammer and firing the cartridge. (3)
- The hammer can either be cocked again or the trigger can be pressed once more. (4)
- Once all of the cartridges have been fired, the cylinder release can be depressed once

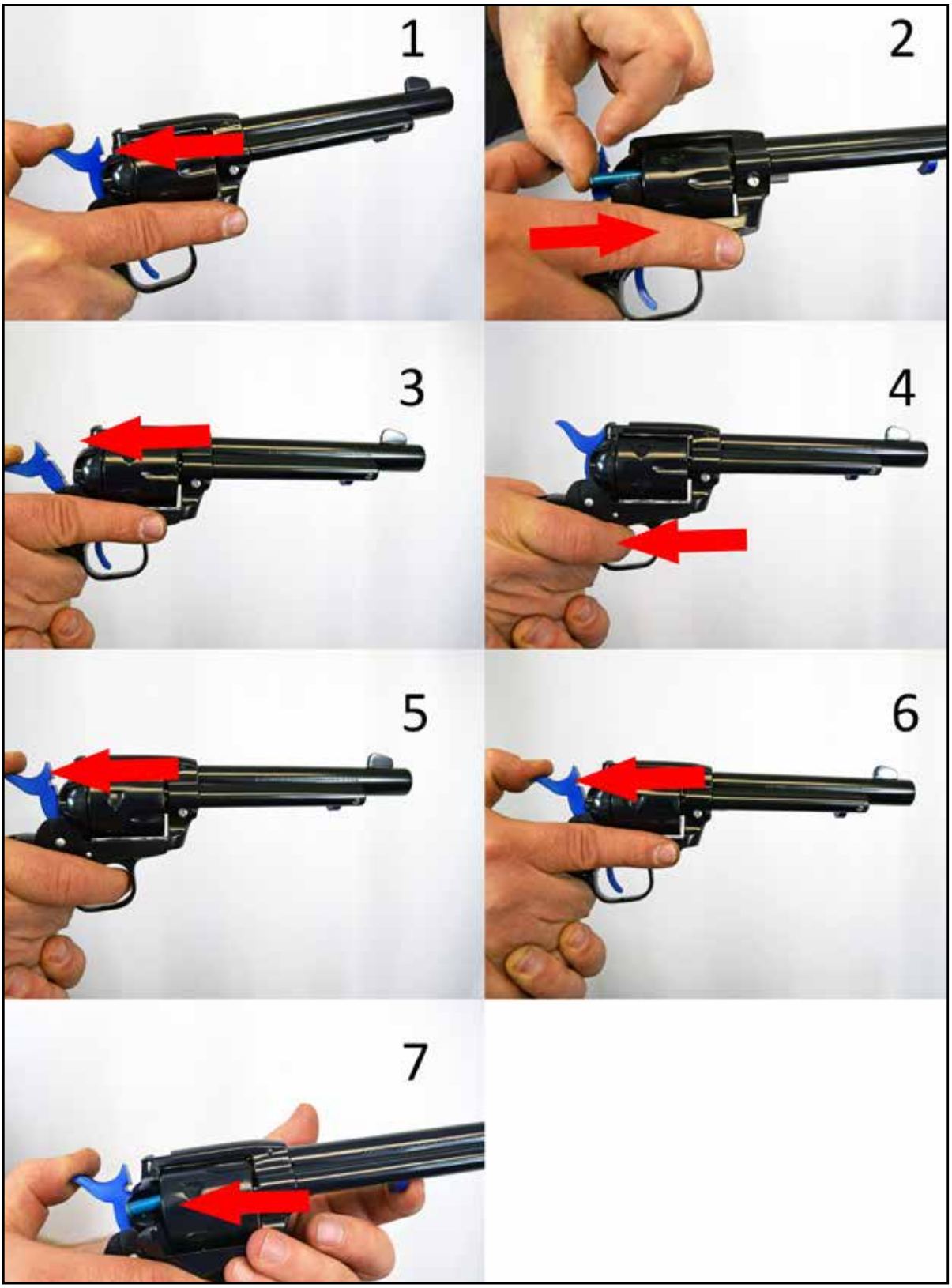


Figure 18: Single-action revolver cycle of operations.

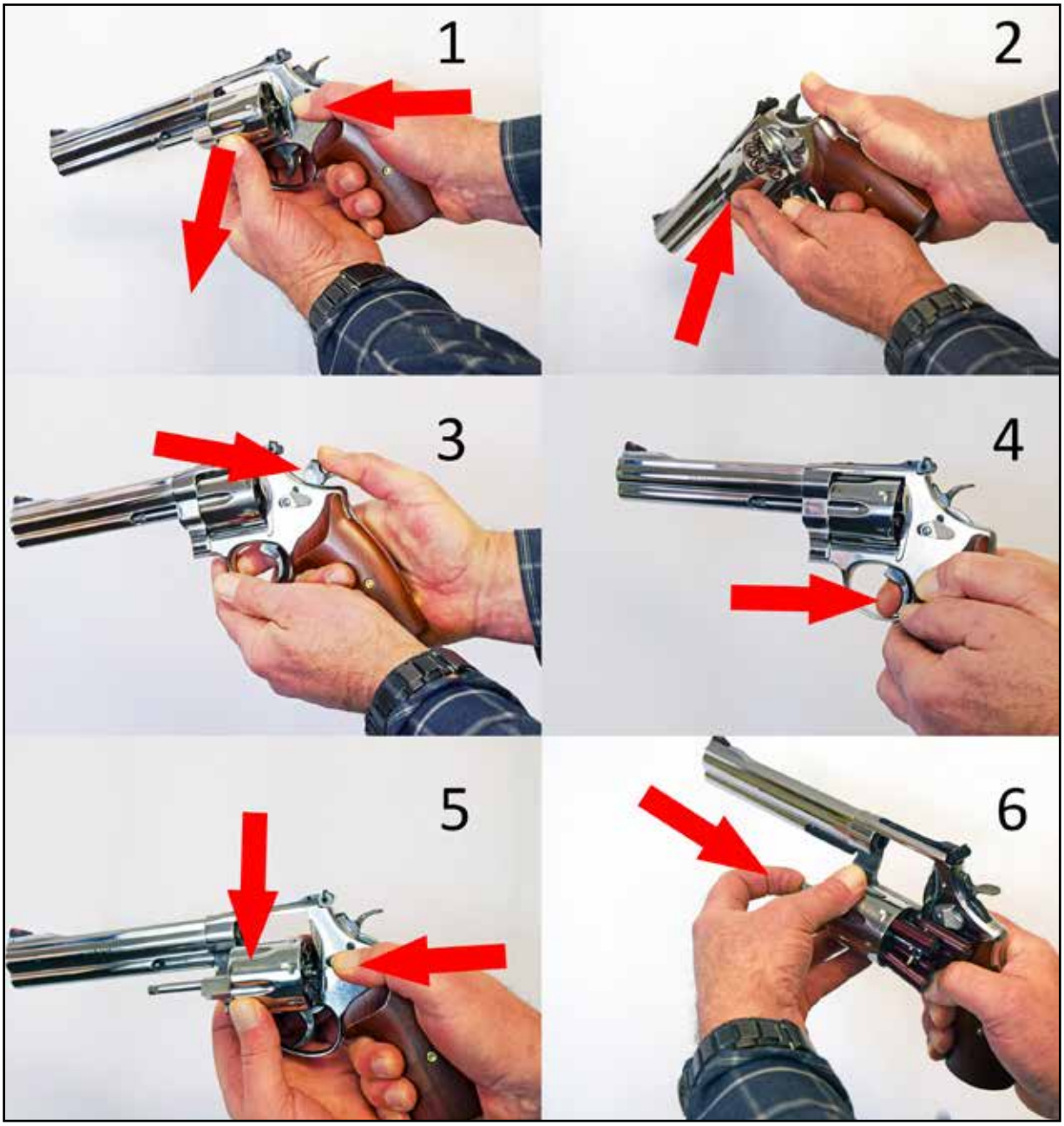


Figure 19: Double-action revolver cycle of operations.

more. The cylinder can be swung away from the frame and expose the chambers. (5)

- The ejector rod is depressed, extracting and ejecting all chambers simultaneously. (6)

The action is now open, the chambers are exposed, and the firearm is ready to be loaded once again.The revolver-style action is the oldest repeating firearm action, with examples dating as far back as 1600 A.D. The revolving feeding mechanism evolved over the years from muzzleloading matchlock and flintlock systems and breechloading percussion cap systems to its present form of modern centerfire, metallic cartridge breechloading systems. There have also been many variations of the revolver action, including several break-action revolvers and a couple of semi-automatic revolvers.

The revolver-style action is not only unique in its design and operation, the firing process also differs. Unlike the previous action types, where all of the pressure from the discharging cartridge is contained within the chamber and bore of the firearm, some pressure escapes the revolver action prematurely. By design, the barrel and chamber are separate pieces. When the cartridge is discharged, the projectile has to jump a small gap from the cylinder into the forcing cone of the barrel. This gap presents a dangerous scenario if a part of the shooter's hand gets too close.

This drawback is also a bonus of the revolver design. Squib loads may not catastrophically disassemble a revolver like they do other firearms because this gap acts as a pressure relief valve. It is not uncommon to work on revolver barrels with 8–15 bullets stacked up in them.

The revolver action has proven itself to be extremely reliable and robust, making the revolver a preferred choice for self-defense. By design, the revolver action is not prone to the types of malfunction of other action types. Even if the cartridge fails to fire, simply cocking the hammer or pressing the trigger will load a fresh round.

Figure 20: Several different revolvers.

Revolvers do not typically jam from feeding or extracting/ejecting issues either. The revolver-style action is very easy to operate once loaded, especially with double-action systems. Revolvers are also capable of handling very powerful cartridges as well as very low-powered ones.

Although the revolver action is extremely reliable and easy to use, it has one major downfall. Revolvers have an extremely limited capacity, typically five to eight rounds. Coupled with a fairly slow loading procedure, rate of fire suffers significantly. Regardless of the limited capacity, the revolver action has withstood the tests of time, rigors of battle, and service around the globe, with countless more years ahead.

Semi-Automatic and Automatic Action

Unlike manual actions, which require the operator to perform many of the steps of the cycle of operations, semi-automatic and automatic actions are almost completely automated. They rely on the energy and pressure generated by the discharging cartridge to unlock the chamber, extract and eject the empty case, cock the hammer/striker, and feed and lock the chamber once again. The operator only needs to load the firearm or insert a loaded feeding device. Once all of the cartridges have been fired, the firearm can simply be reloaded.

The difference between semi-automatic and automatic actions lie mostly in the fire control group. With a semi-automatic action, when the trigger is pressed the firearm will fire one round, and the action will cycle. To fire another round, the trigger will need to be released until it resets, then another round can be fired. When the trigger is pressed with an automatic action, the firearm will continue to fire until the trigger is released or the feeding device is empty. Regardless of being semi or automatic, the rest of the cycle of operations will remain the same.

BLOWBACK OPERATION

The blowback-style action is so named because of the fact that the energy from the discharging cartridge simply blows the bolt/slide backward, automatically completing many of the steps in the cycle of operations. The blowback-style action is used with pistols, rifles, and shotguns. With an empty and locked action, the cycle of operations for a semi-automatic blowback-style action firearm is as follows:

- Depending on specific model, the firearm is loaded, either directly into an internal fixed magazine or through a removable magazine. (1)
- The operator must manipulate the action by means of charging handle or slide.

Figure 1: Semi-automatic firearms.

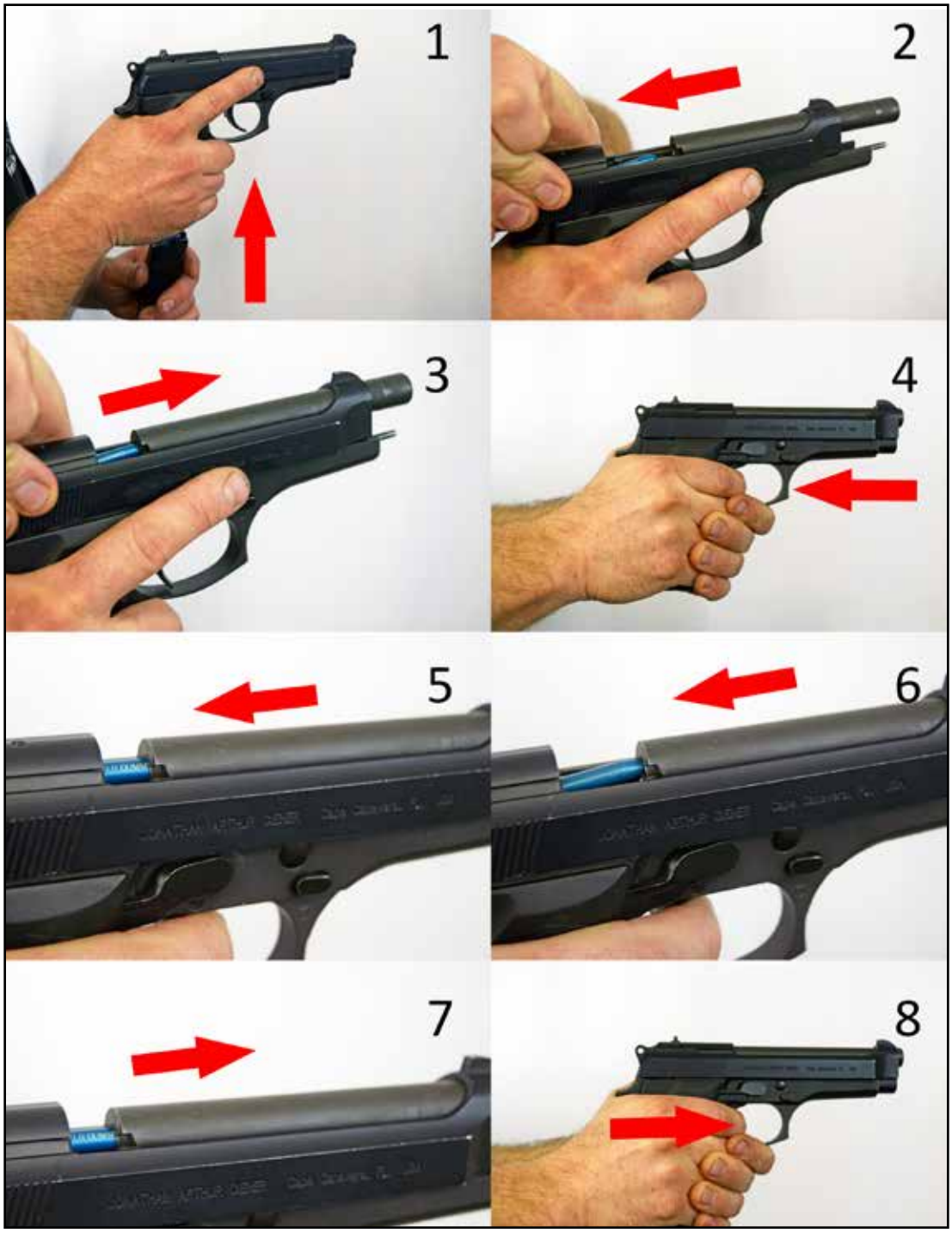


Figure 2: Blowback action cycle of operations.

The charging handle/slide is pulled to the rear of the firearm, opening the chamber and breech and cocking the hammer/striker. At the same time, a fresh cartridge has been automatically fed, in line with the bolt/slide. (2)

- The action spring will drive the bolt/slide forward, stripping a round from the magazine and driving it into the chamber. The moment the barrel and bolt/slide meet, the chamber is "locked." (3)
- The trigger is pressed, releasing the hammer/striker and discharging the round. (4)
- The energy from the cartridge is transferred to the bolt/slide, which overpowers the action spring and drives it rearward. As the bolt begins to move back, the extractor begins to pull the empty case from the chamber. (5)
- The cartridge's energy will continue to drive the bolt/slide rearward. Depending on the model, the ejector may be part of the bolt or part of the frame/receiver. When the bolt/slide has reached the end of its stroke, the ejector will kick the empty case from the breech. Simultaneously, the bolt/slide will cock the hammer/striker. A new round will be fed in line with the bolt/slide. (6)
- Again, the action spring will drive the bolt/slide forward, stripping a round from the magazine and driving it into the chamber. The moment the barrel and bolt/slide meet, the chamber is "locked." (7)
- If the trigger is still being pressed, it must be released to the reset position in order to fire the next round. If the trigger was already reset, it can be pressed again to fire the next round. (8)

Of all of the semi-automatic/automatic actions, the blowback action is the simplest. Unlike other action types, the blowback action does not employ a true locking breech system. The blowback action relies on the weight of the bolt/slide and the strength of the recoil/action spring to hold the breech closed during discharge. The action may also employ other methods to help delay the opening of the chamber.

The blowback action utilizes the momentum in the bolt from the cartridge being discharged. When the round is fired, pressure will build in the case and cause it to expand and seal itself against the chamber walls. The case will also begin to push against the bolt/slide face. The bullet will be pushed into the bore while the case begins to push rearward against the bolt/slide. Once the bullet has exited the muzzle and pressure begins to drop in the bore and chamber, the case will begin to contract and the inertia in the bolt/slide will be great enough to overcome the recoil/action spring and drive it rearward.

Because the chamber of the blowback action is not physically locked, the action is typically reserved for rimfire and low power pistol rounds. Higher power cartridges require extra closing force or the movement of the bolt to be slowed. There are two basic types of blowback actions: straight or simple and delayed.

- **Straight/Simple Blowback** – Of the blowback systems, straight blowback is as simple as it gets. The straight blowback system utilizes a barrel and bolt/slide that simply butt up against each other to close the chamber. When the action cycles, the bolt/slide moves straight, in line with the barrel. Only the weight of the bolt/slide and the strength of the action/recoil spring are used to secure the chamber during discharge.

  Because the chamber does not mechanically lock and the case begins pushing against the bolt/slide from the moment

of discharge, the action cycles very quickly. With semi-automatic actions, this means the operator experiences less "felt" recoil. This means the actual amount of recoil delivered may be greater, but because the recoil impulse is so brief, the operator does not feel the force as greatly. This also means that a high rate of fire can be achieved with enough skill. With automatic actions, a fast cycling action means a high rate of rounds-per-minute (rpm). While most locking breech automatic firearms have a cyclic rate of around 600 – 900 rpm, automatic blowback firearms cycle around 1,100 – 1,200 rpm.

Major drawbacks to the straight blowback design include a limited selection of chamberings, ammunition selection, and feeding issues.

Certain ammunition can also create various problems for the straight blowback action. Because there are various types of ammunition for single rimfire caliber, it would be hard to design an action (that relies on the ammunition's energy) to run with every type. Most manufacturers tune their firearms to run with a specific type and even brand of ammunition, ensuring the most reliable function. Using ammunition that is not recommended can lead to various issues. Using ammunition that is below the manufacturer's recommended power level can lead to failures to extract and eject, failure to cock the hammer/striker, and failure to feed and lock the chamber. Using ammunition that is more powerful than the manufacturer's recommendations can cause the bolt/slide to batter the frame because it was not designed to handle so much power. It can also cause failures to extract when the extractor slips over the case rim because the case is not ready to contract and the case becomes stuck in the chamber. As well, it can cause a failure to feed when the bolt/slide outruns the feeding device and the bolt/slide runs over top of the round or only catches the edge of the round.

Figure 3a: Straight blowback pistol.

The components of the cartridge itself may also cause further malfunctions to the blowback action. Rimfire cartridges typically use solid lead projectiles and propellant that burns fairly dirty. Lead will build up in the throat of the chamber and bore, and carbon and unburned propellant will build up in the firearm's action. If left untreated, this buildup can lead to seizure of the action parts and various malfunctions.

The straight blowback action is one of the most popular action types, with some variation being employed by various manufacturers. The action is typically simple and cheap to manufacture

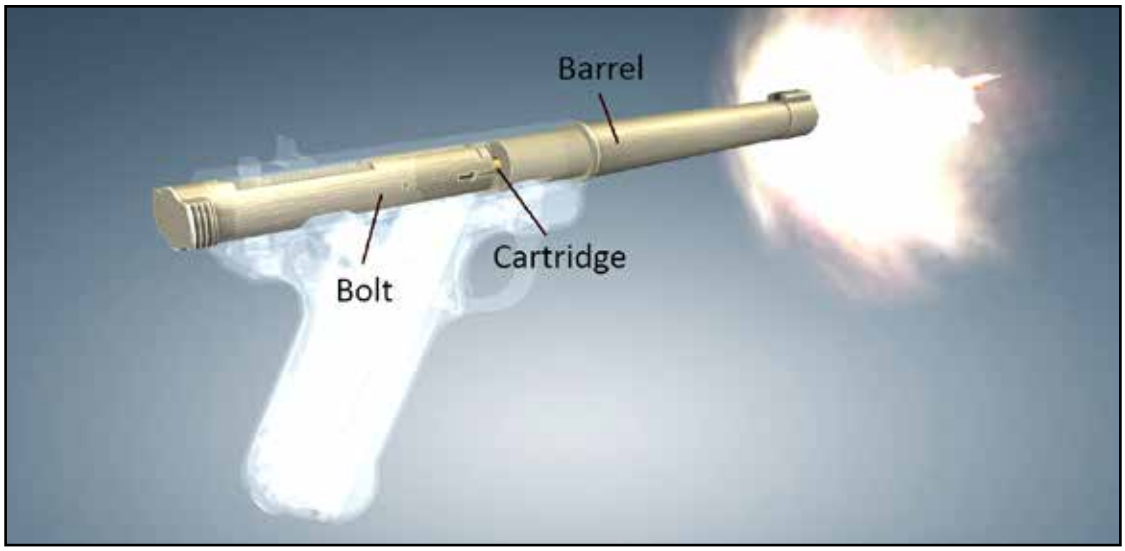


Figure 3b: Straight blowback pistol.

and ammunition is cheap and plentiful, which makes them a perfect "first gun" for new shooters. Most of these firearms are chambered in .22 Long Rifle, one of the most popular cartridges of all time. With the popularity of the action and ammunition, the straight blowback action is showing no sign of becoming obsolete any time soon.

A "floating chamber" works on the same principle as the straight blowback action, but as an action within an action. The floating chamber was designed to convert larger caliber firearms into more economical, recoil-friendly training tools. The floating chamber allows the firearm to operate in basically the same manner, with the only exception being the chamber does not lock. Typically, the bolt is replaced with a self-contained unit, which incorporates a chamber, partial barrel, bolt, and action/recoil spring.

The floating chamber lives inside of the action of the converted firearm. The floating chamber will perform all of the functions of the cycle of operations for

Figure 4: .22 LR conversion kit.

a semi-automatic action while utilizing the controls and ergonomics of the host firearm. Once training is complete, the floating chamber can be removed and the original caliber bolt can be replaced. This allows the operator to practice the manual of arms for the given firearm, while using low cost ammunition.

- **Delayed Blowback** – The delayed blowback system works in a similar manner to the straight blowback action, but uses an additional system to help hold the chamber closed during discharge. The delayed blowback system was developed so that more powerful cartridges could be used with the simplicity of the blowback system. The delayed blowback system uses various methods to slow the opening of the chamber. These methods include roller, lever, gas, chamber ring, hesitation lock, toggle, and off-axis bolt travel.
  - **Roller Delayed** – Like its name implies, the roller delayed blowback system relies on "rollers" to slow the bolt's movement during discharge. The system utilizes a multi-piece bolt design, with a bolt head, carrier, carrier extension (wedge), and rollers. When the chamber is closed, the bolt head and carrier will compress into each other, causing the carrier extension to drive the rollers into recesses in the receiver.

    Like other blowback actions, during discharge the cartridge case will begin driving the bolt head rearward. The bolt head instantly begins forcing the rollers back. The rollers, being limited in movement by the receiver, begin to move inward against the carrier extension and drive the carrier extension and carrier backward. This happens with so much force that the carrier accelerates faster than the bolt head, delaying the bolt head's movement. The rollers move inward, clearing the cutouts in the receiver.

Figure 5a: Roller delayed blowback action.

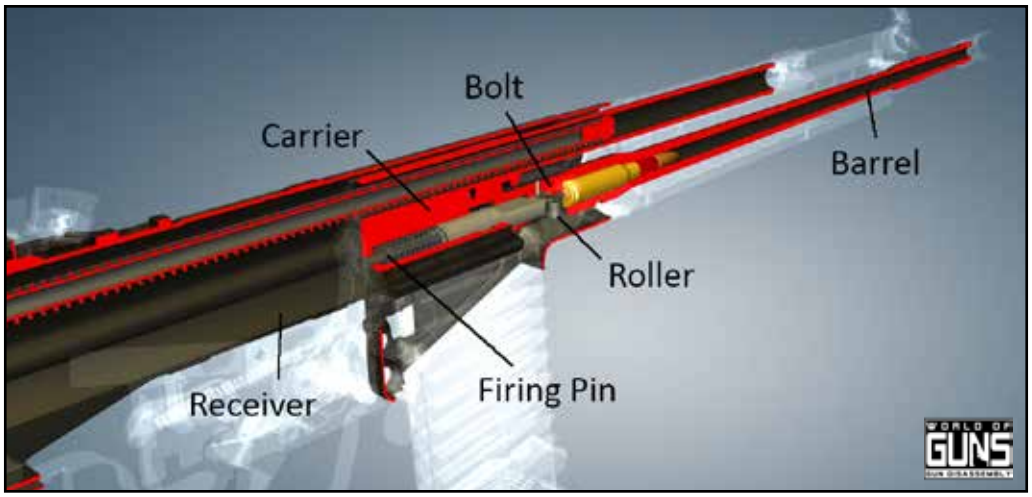


Figure 5b: Roller delayed blowback action.

The carrier will continue to move rearward, pulling the bolt head with it, which, in turn, extracts the empty case from the chamber, ejects it, and cocks the hammer. The action/recoil spring drives the bolt and carrier forward, stripping a round from the magazine and feeding it into the chamber. The bolt will bottom out against the cartridge and the barrel, while the carrier will continue to move forward, driving the extension into the rollers and forcing the rollers into the cutouts in the receiver.

The roller delayed blowback action allows the use of higher power cartridges while maintaining much of the simplicity of the blowback action. The delayed blowback action is capable of handling most pistol cartridges and a handful of rifle cartridges. The action has found extreme success with the Heckler & Koch G3 (7.62x51 NATO semi-automatic/select fire rifle/carbine) and the MP5 (9x19mm Parabellum semi-automatic/select fire SMG). The roller delayed blowback action should not be confused with the short stroke, recoil-operated roller lock-action, which utilizes a mechanically locking breech design.

- **Lever Delayed** – Like the roller delayed action, the lever delayed action is accurately named by means of resistance. The lever delayed system relies on leverage from a lever to slow the chamber's opening. This may seem counterintuitive because levers are typically used to reduce the amount of force required to move something. This is true if you are using a lever for its mechanical advantage, but the lever can also be used for mechanical disadvantage.

  For example, a lever has a pivot point (fulcrum) and two connected arms (typically one long and one short). The short arm is called the resistance arm and the long is called the effort arm. When used for mechanical advantage, force applied to the effort arm will be transferred and multiplied to the resistance arm. This will allow you to generate great force with minimal effort, like moving a large boulder

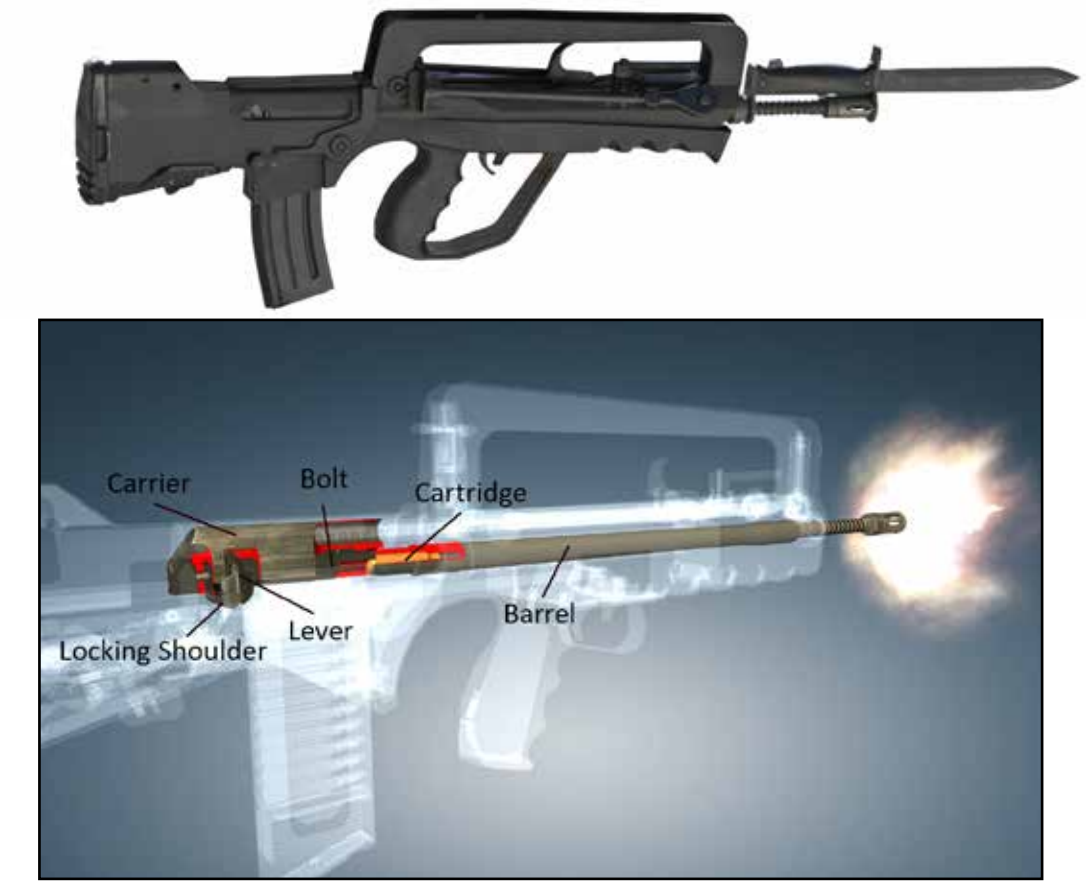


Figure 6a & 6b: Lever delayed blowback action.

with a log. This also requires a greater range of motion from the effort side.

When used for mechanical disadvantage, force is applied to the resistance arm. The resistance arm will resist the force being applied, while pivoting around the fulcrum and transferring force to the effort arm. Any slight movement of the resistance arm will be magnified in movement of the effort arm.

The lever delayed blowback system relies on the mechanical disadvantage that can be created by a lever. The system utilizes a two-piece bolt/carrier assembly and a lever. During discharge, when the case begins to force the bolt head rearward, it instantly begins acting against the lever. The resistance arm rests in a slot in the receiver against a leverage surface. When the bolt moves back, the resistance arm will instantly bottom out against the receiver and cause the lever to rotate, driving the effort arm into a slot in the carrier. The slight movement of the resistance arm causes the effort arm to drive the carrier rearward at a greater velocity than the bolt. This causes the bolt to slow and the chamber to delay opening.

As the bolt continues to move rearward and the lever pivots, the effort arm will move out of contact with the carrier. The momentum generated by the velocity of movement of the effort arm and the weight of the

carrier will overcome the inertia of the action/recoil spring and continue to drive the carrier rearward, pulling the bolt and cartridge case with it. The bolt and carrier will now move rearward at the same speed. On its rearward travel, the bolt will extract the case from the chamber and eject it and cock the hammer.

Once the bolt has reached the end of its stroke and the action/recoil spring has almost fully compressed, the bolt will begin to be driven forward. On its forward travel, the bolt will strip a round from the magazine, drive it into the chamber and seat it completely. The bolt will bottom out against the barrel and cartridge and the carrier will continue forward, pushing against the effort arm of the lever and causing it to rotate into place in the groove in the receiver.

The lever delayed blowback system is capable of handling much higher pressures than a standard blowback operation. The lever delayed blowback action is most commonly associated with the French MAS FAMAS F1 and G2 rifles. These bullpup-style rifles are chambered in 5.56x45 NATO and were adopted by the French military in 1978. The action has also found use in many other firearms, including pistols, assault rifles, and machine guns.

- **Gas Delayed** – The gas delayed blowback action is similar but different, and should not be confused with the gas-operated action. Unlike the gas-operated system, which uses a locking chamber and tapped gasses to unlock it, the gas delayed blowback system uses those same gasses to delay the chamber opening. Instead of the gasses acting against the bolt/slide trying to push it rearward and open it, the gas delayed blowback system directs those same gasses into a cylinder under the barrel that pushes forward, against a piston that forces the bolt/slide closed.

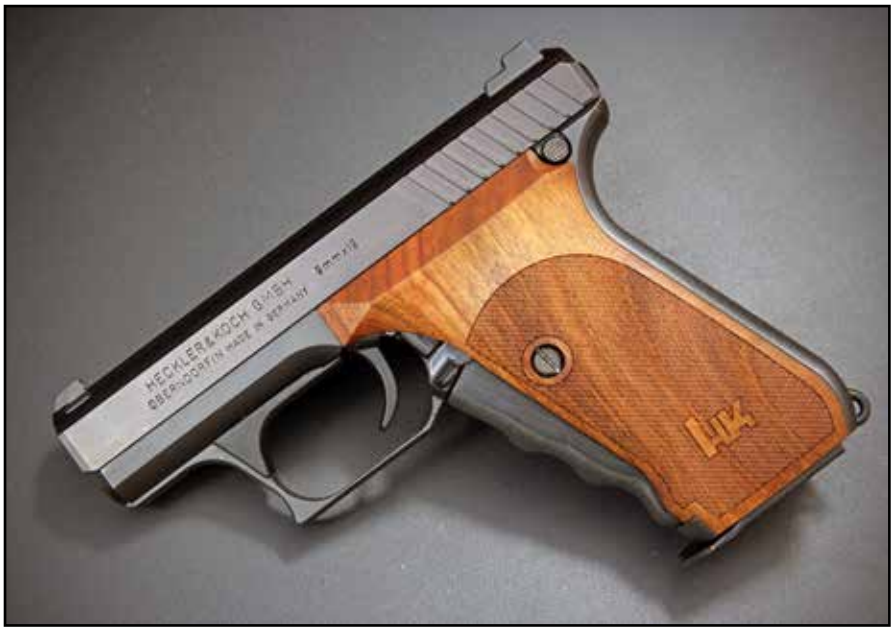


Figure 7: Gas delayed blowback action.

During discharge, a small amount of gas is tapped from the bore just ahead of the chamber. This gas is directed down, into a cylinder under the barrel. One end of the cylinder is sealed by a piston that is attached to the bolt/slide. As the bullet travels through the bore, the cylinder becomes fully pressurized and the same gas begins to push against the case and the bolt/slide face. The bolt/slide is stopped by the piston acting against the pressurized cylinder. When the bullet exits the muzzle and the gasses are allowed to escape, the cylinder will depressurize and the inertia in the bolt/slide will overcome the action/recoil spring and move rearward.

On its rearward travel, the bolt/slide will pull the empty case with it, extracting it from the chamber and ejecting it farther back in its travels. The bolt's/slide's movement will also cock the hammer. On its forward travel, the bolt/slide will strip a new round from the magazine and feed and seat it in the chamber. When the bolt/slide bottoms out against the barrel, the chamber is fully closed.

The gas delayed blowback action saw moderate use during WWII with Germany and the Volkssturmgewehr 1-5 rifle and the Grossfuss Sturmgewehr, both chambered in 7.92x33 Kurz. The design was later picked up by Heckler & Koch (P7), Walther (CCP), and Steyr (GB). The delayed-blowback action has been typically reserved for pistol caliber cartridges even though it has been employed by pistols and rifles.

› **Chamber Delayed** – The chamber delayed blowback system can be seen in a few different configurations. The chamber-ring delayed blowback action is by far one of the simplest means of slowing the chamber's opening. Unlike the other systems that rely on external, mechanical means to slow the chamber's opening, the chamber delayed system utilizes a simple design feature in the chamber to impede the action from opening during discharge. One system uses a ring cut in the chamber

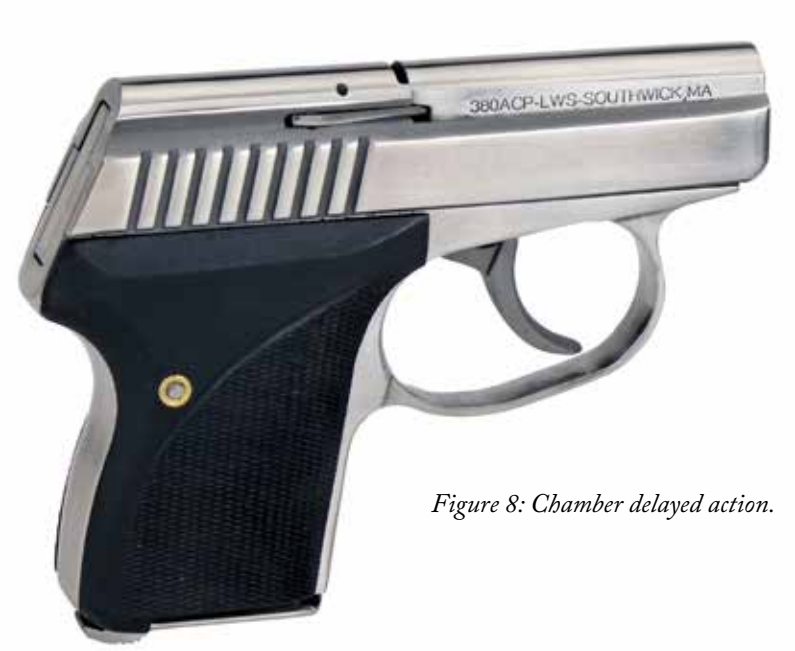


Figure 8: Chamber delayed action.

the other system uses dimples cut into the chamber. During discharge, when the case swells from the building pressure, it will form to the chamber. The chamber with either the ring or dimples will slow the case and impede rearward movement. Once the bullet exits the muzzle, the pressure inside the bore drops and the case begins to shrink; the case will then begin to drive the bolt/slide rearward. On its rearward stroke, the bolt/slide will extract and eject the case and cock the hammer. On its forward stroke, the bolt/slide will strip a piece of ammunition from the magazine and feed and seat the cartridge in the chamber.

- During discharge, when the case swells from the building pressure, it will form to the chamber. The chamber ring will slow the case and impede rearward movement. Once the bullet exits the muzzle, the pressure inside the bore drops and the case begins to deflate; the case will then begin to drive the bolt/slide backward at a higher velocity. On its rearward stroke, the bolt/slide will extract and eject the case and cock the hammer. On its forward stroke, the bolt/slide will strip a round from the magazine and feed and seat the cartridge in the chamber.

  The chamber delayed action is only found with one model of pistol from the L. W. Seecamp Co. The LWS-32 is a chamber delayed blowback pistol chambered in .32 ACP. There is also a model chambered in .380 ACP. The AMT .22 Mag pistols used a similar system but had small dimples instead of a complete ring.

- **Hesitation-Lock Delayed** – The hesitation-lock delayed action does not use a locking chamber design; it is a delayed blowback-style action that uses a locking design to slow the bolt. The hesitation-lock delayed blowback design utilizes a combination bolt/slide and locking block to delay the chamber's opening. The bolt head and slide move independently of each other, but are also connected.

  During discharge, when the cartridge case begins pushing the bolt/slide backward and the chamber begins to

Figure 9: Hesitation-lock delayed action.

Figure 10: Toggle delayed blowback action.

open, the bolt's movement is stopped by the locking block shoulder. The slide will continue rearward, while the bolt remains stationary, until the slide trips the locking block release, which allows the bolt to continue rearward with the slide. Momentarily stopping the bolt's movement allows the bullet to exit the muzzle and the pressure inside the bore to drop.

As the slide continues rearward, the bolt will strip the empty case from the chamber and eject it and cock the hammer. On its forward travel, the bolt will strip a round from the magazine and feed and seat it in the chamber. The bolt head will bottom out against the barrel, fully closing the chamber, and the slide will collapse against it.

There is only one known production firearm that uses the hesitation-lock delayed action. The Remington® Model 51 is a semi-automatic, hesitation-lock delayed blowback pistol chambered in .32 and .380 ACP. The Model 51 saw very high production numbers (65,000) from 1918 into the 1930s. Remington revamped the Model 51 in 2014 as the R51, which still uses a hesitation-lock design, but changed the blowback operation to recoil-operated locking chamber operation.

- **Toggle Delayed** – The toggle delayed action should not be confused with the toggle lock action. The toggle delayed action, like other delayed blowback actions, does not feature a locking chamber, but rather a chamber that is simply held close. The toggle delayed action utilizes a toggle mechanism to slow that chamber's opening. The design of the toggle creates a mechanical disadvantage similar to the lever delayed system.

  The toggle delayed blowback action uses a multi-piece breechblock that is pinned together forming multiple hinge joints. The front of the

breechblock is called the head and is pinned to the center piece. The center piece of the breechblock is pinned to the head and end piece and is called the body. The opposite end of the breechblock is pinned to the receiver and is called the crank. In the closed position, the pieces of the breechblock are parallel, in line with the bore. When the breech is completely open, the body and crank will pivot upward, almost vertically.

When the cartridge case begins to push against the breech head during discharge, the head will immediately transfer energy back through the body and crank. Bearing surfaces on the body, the crank and receiver force the body/crank joint to begin to rise. The breech head will continue rearward (in a straight line) while the body and crank continue to pivot upward. The energy required to drive the crank upward is enough to slow the action's opening until the bullet has exited the muzzle and the pressure inside the bore and case has dropped. The breech head will continue rearward, extracting the case and ejecting it and cocking the hammer. At this point, the action has reached the rear of its stroke and the crank has pivoted over 90 degrees from its closed position.

The action/recoil spring will drive the breech head forward, stripping a fresh round from the magazine and feeding and seating it in the chamber. The body/crank joint will pivot down until the body and crank are parallel to the breech head and the bore. Once the breech head bottoms out against the barrel, and the head, body, and crank are all in line, the chamber is fully closed.

The most notable use of the action was with the Pedersen rifle. The T1E3 is a toggle delayed blowback, semi-automatic rifle chambered in .276 Pedersen. The rifle was almost selected as the Army's newest service rifle in the 1930s but was passed over by the M1 Garand because of ammunition issues. The designer of the Pedersen rifle, John Pedersen, also

Figure 11a: Off-axis bolt travel delayed blowback action.

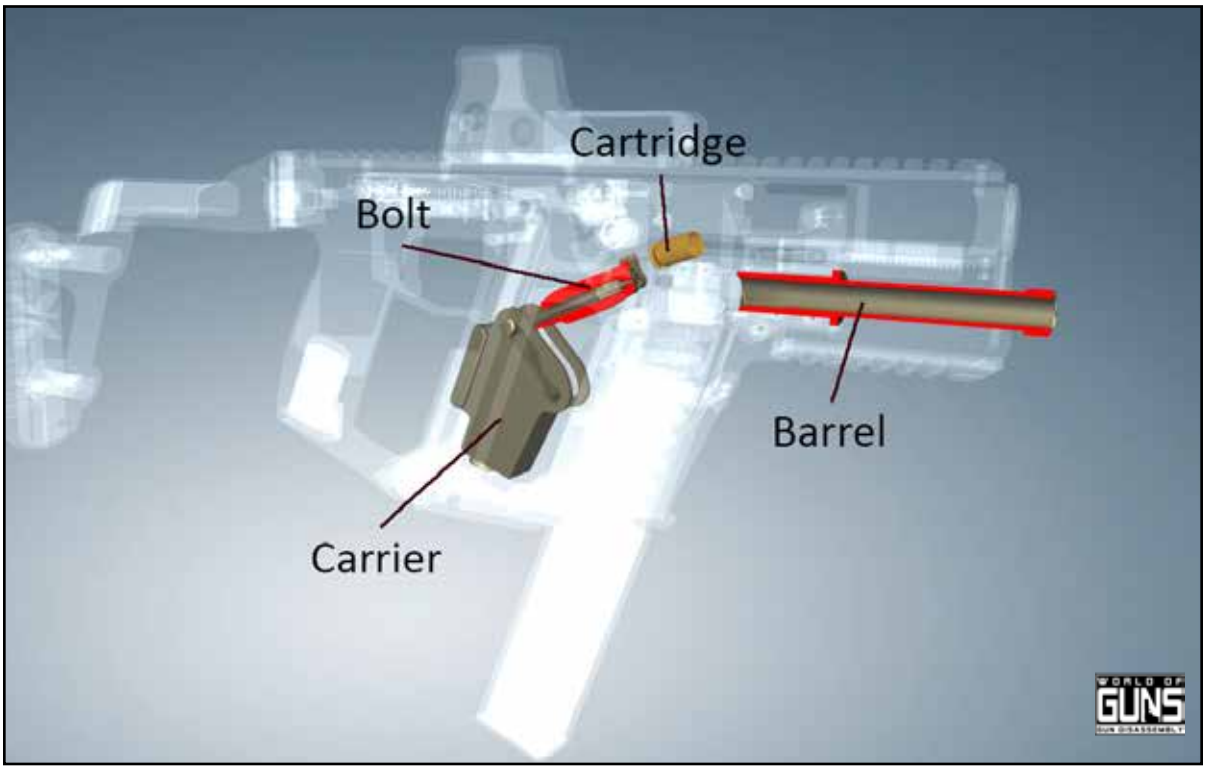


Figure 11b: Off-axis bolt travel delayed blowback action.

designed the hesitation-lock delayed blowback action.

› **Off-Axis Bolt Travel Delayed** – The off-axis bolt travel delayed action differs from all other blowback actions in the fact that with every other action type, the bolt/breech head/slide moves in line with the bore, while with the off-axis delayed action, the bolt moves at an angle to the bore. There are two different types of this action, depending on whether the bolt's movement is above or below the bore's axis.

The bolt may be a single piece or use an additional carrier or slider. During discharge, when the cartridge case begins pushing back against the bolt, the bolt will move in guides in the receiver/slide at an angle away from the bore's axis. This off-axis movement away from the direction of the bolt's momentum causes the bolt's movement to slow because of the mechanical disadvantage that is created. The momentum in the bolt from the discharged cartridge wants to push the bolt rearward in line with the bore, but rails or guides in the frame direct the bolt in a direction away from the direction of momentum, creating enough resistance to keep the chamber closed until the bullet has exited the muzzle and pressure inside the bore has dropped.

As the bolt continues rearward on its off-axis travel, it will extract the empty case from the chamber, eject it, and cock the hammer/striker. The action/recoil spring will push the bolt forward, stripping a fresh round from the magazine and feeding and seating

it in the chamber. Once the bolt has bottomed out against the barrel, the chamber is fully closed.

The off-axis bolt travel delayed blowback action has seen a fair amount of use in modern times, with several firearms employing it. The design is popular because of the inherent design advantage. Because the bolt does not move in line with the bore, the recoil impulse is delivered in a different manner, which significantly reduces the amount of felt recoil. The Finnish Jatimatic 9mm submachine gun and French MAS-38 both employ the off-axis action design. The bolt of the Jatimatic moves at an upward angle to the bore, while the MAS's bolt moves at a declining angle. Recently, the action has been utilized by the KRISS® Vector. The Vector can be configured as a pistol, rifle, or SBR, and has multiple chamberings from 9x19mm NATO to 10mm Auto.

FLUTED CHAMBERS

The fluted chamber is a design feature that is found most commonly with blowback actions. The purpose of the fluted chamber is to ease the empty case's extraction. The system utilizes gasses from the discharging cartridge to flow between the cartridge case and chamber and to prevent the case from sticking.

The fluted chamber design features slots cut around the chamber parallel to the bore, typically spaced farther forward in the front of the chamber. During discharge, a small amount of high pressure gas is channeled to the flutes, which creates a pillow of air for the case to float inside the chamber. This pillow of air prevents the cartridge case from sticking to the chamber walls and makes extraction much easier.

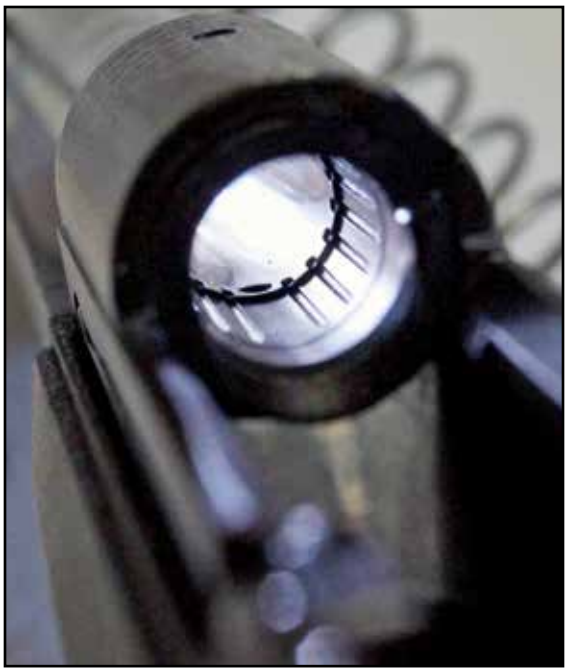


Figure 12: A fluted chamber.

The fluted chamber is very advantageous for blowback firearms because they tend to be very finicky with various types of ammunition. Any friction between the cartridge case and the chamber walls can dissipate enough energy from the system to cause malfunctions. The system has worked so well for the blowback-style action that other action types, like the recoil and gas-operated actions, have begun to adopt it to help with harsh extraction.

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Recoil Operation

The recoil operation action is similar to the blowback-style action in the respect that both use energy from the discharging cartridge, but the recoil operation action utilizes a locking breech designed to handle more powerful cartridges. Recoil operation is based on Newton's Third Law of Motion: For every action, there is an equal and opposite reaction. The recoil operation-style action is used with pistols, rifles, and shotguns.

With an empty and locked action, the cycle of operations for a semi-automatic recoil operation-style action firearm is as follows:

- Depending on the specific model, the firearm is loaded, either directly into an internal fixed magazine or through a removable magazine. (1)
- The operator must manipulate the action by means of charging handle or slide. The charging handle/slide is pulled to the rear of the firearm, opening the chamber and unlocking the breech and cocking the hammer/striker. At the same time, a fresh cartridge has been automatically fed, in line with the bolt/slide. (2)
- The action spring will drive the bolt/slide forward, stripping a round from the magazine and driving it into the chamber. Depending on the specific recoil action being employed, the chamber may lock in various ways. Lugs on the bolt/slide and receiver are common means of locking the chamber. (3)
- The trigger is pressed, releasing the hammer/striker and discharging the round. (4)
- The recoil energy from the bullet being forced through the barrel is transferred back into the action. The lugs on the barrel/slide and frame are pushed into each other, forcing the chamber closed. The breech will remain locked until the bullet has left the barrel and the pressure inside the bore has dropped. Once the case has deflated and released its friction lock from the chamber, the recoil energy will begin to drive the barrel and action rearward, unlocking the chamber. Depending on the specific model, the barrel and bolt/slide may move together a long or short distance before unlocking. (5)
- The recoil energy will continue to drive the bolt/slide rearward (possibly still with the barrel). Depending on the model, the ejector may be part of the bolt or part of the frame/receiver. When the bolt/slide has reached the end of its stroke, the ejector will kick the empty case from the breech. Simultaneously, the bolt/slide will cock the hammer/striker. A new round will be fed in line with the bolt/slide. (6)
- Again, the action spring will drive the bolt/slide forward, stripping a round from the magazine and driving it into the chamber. The chamber will once again lock. (7)
- If the trigger is still being pressed, it must be released to the reset position in order to fire the next round. If the trigger was already reset, it can be pressed again to fire the next round. (8)

The main defining feature most recoil-operated actions have is the recoiling barrel. Blowback and gas-operated actions all use fixed barrels and moving actions, while most recoil-operated firearms rely on the energy from the barrel recoiling to cycle the action. The only exception to this is the modern inertia operated action, which utilizes a fixed barrel. The recoil-operated action is not as simple as the blowback but is still less complex than other action styles. There are several styles of recoil-operated firearms based on the movement of the barrel and the bolt/slide and the way the chamber locks.

Figure 13: Recoil operation action cycle of operations.

Like other action types that rely on the energy created by a discharging cartridge, recoil-operated action firearms can be finicky with certain ammunition types. Recoil-operated firearms are also susceptible to human error. Most recoil-operated firearms are designed to run with a general range of ammunition that will generate enough energy to sufficiently cycle the action; but rounds that are designed to be stronger or weaker than normal can cause malfunctions in a recoil-operated firearm. Also, because the firearm is designed for part or most of the action to move in order to cycle the action, the operator can cause malfunctions by not securing it during discharge. If the entire firearm is allowed to recoil too much instead of just the parts that need to move, the energy needed to cycle the action will be dissipated by the entire firearm moving.

Recoil-operated firearms are some of the most common action types used with modern day semi-automatic firearms. Recoil operation can be divided into three major operation types, with several subcategories of action. The three major categories of recoil-operated actions are long recoil, short recoil, and inertia.

- **Long Recoil** – The long recoil-operated action gets its name from the fact that the barrel and bolt/slide travel near to all the full distance of the action's travel. This differs from other recoil-operated actions where the barrel may only move a short distance compared to the rest of the action. The long recoil action is very unique in design and was very popular early in the 20th century.

The long recoil action utilizes a spring barrel and one-piece bolt design. During discharge, the pressure inside the chamber will cause the locking surfaces to hold it closed until the bullet has exited the bore and pressure has dropped. The barrel will begin to move backward, driving the bolt with it. The barrel and bolt will continue to move backward until they bottom out against the rear of the receiver, at which point a return spring will drive the barrel forward while the bolt and empty case are held in place by a catch.

The barrel will continue forward while the bolt stays behind, extracting the empty case from the moving chamber. When the barrel nears the end of its forward stroke (clearing the ejection port), it will trip the ejector, which kicks the empty case from the breech. The barrel

Figure 14a: Long recoil-operated action.

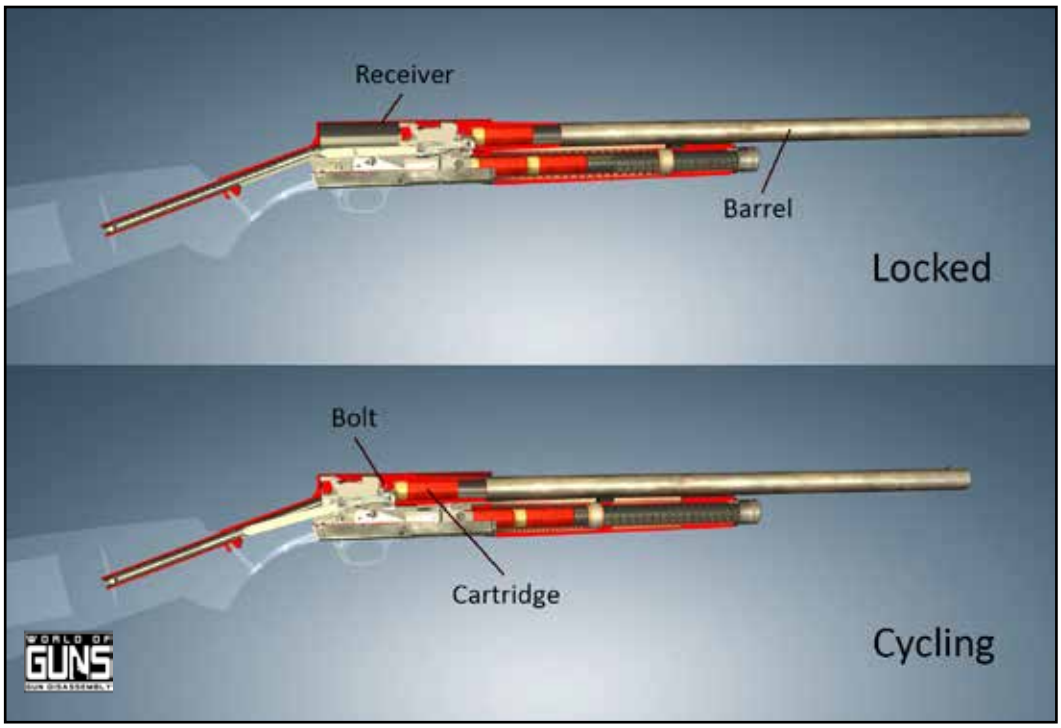


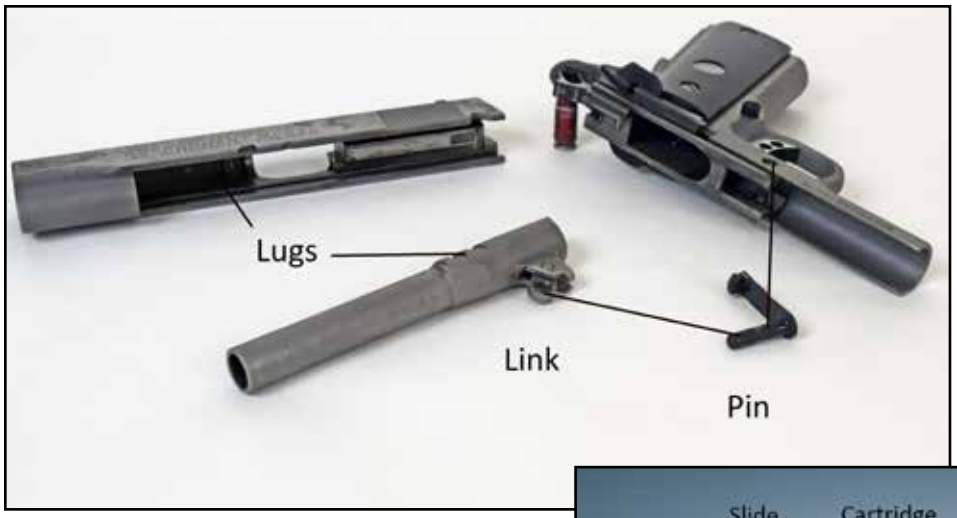
Figure 14b: Long recoil-operated action.

will also trip the cartridge release, which will feed a fresh round into the breech. When the barrel has reached the end of its stroke, it will trip the bolt release. The action/recoil spring will drive the bolt forward, driving the round into the chamber and seating it. Once the bolt and barrel have reached their forward-most position, the locking surfaces will engage and the breech will lock.

The long recoil-operated action tends to be very robust, with a heavy barrel and bolt designed to withstand high power cartridges. This heavy-duty design does have a downside. The mass of the parts combined with the distance of travel lead to a fairly slow-cycling gun. The slow cycling speed does lend itself to greater reliability because the action has more time to perform the cycles of operation.

The long recoil-operated action is one of the oldest recoil-operated actions, with early models in the late 19th century. The long recoil action is primarily found in shotguns, with only a few known examples of rifles (Remington Model 8), and only one known example of a pistol (Frommer Stop). The first semi-automatic shotgun (Browning Auto-5) employed the long recoil action.

- **Short Recoil** – Unlike the long recoil action, where the barrel and bolt/slide travel together almost the entire length of the action's stroke, with the short recoil system the barrel only moves a short distance. The barrel will stop while the bolt/slide continues rearward, completing the cycle of operations. The short recoil system is primarily found with semi-automatic pistols in calibers .380 ACP and up.



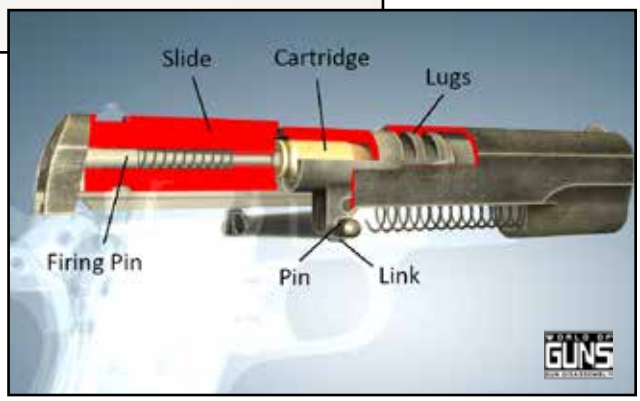


Figure 15a (top) & 15b: Link-type tilting barrel action.

The short recoil system utilizes a moving barrel and slide/bolt, as well as an extra part like a locking block/link to restrain the barrel's movement. During discharge, the pressure inside the chamber will cause the locking surfaces to hold it closed until the bullet has exited the bore and pressure has dropped. The barrel will begin to move backward, driving the bolt with it. The locking block/link will stop the barrel's movement while the bolt/slide continues rearward. On its rearward stroke, the bolt/slide will extract and eject the empty case and cock the hammer/striker. On its forward stroke, the bolt/slide will strip a round from the magazine, feed it, and lock the chamber.

The manner in which the barrel and bolt/slide lock and unlock is the difference between the different types of short recoil systems. Each system has its own advantages and disadvantages, which is why certain types have gained so much popularity. These systems include tilting, rotating, roller lock, toggle lock, and inline.

› **Tilting Barrel** – The tilting barrel action is so named because the rear (chamber end) of the barrel moves downward to unlock the chamber. The action of the barrel tilting is accomplished in several ways. Some models use pivoting links, others use locking blocks and lugs, while others are more simple, utilizing a single lug that has a track machined into it. All of the designs also feature lugs machined into the slide to lock the chamber.

During discharge, the pressure inside the chamber will cause the locking surfaces to hold it closed until the bullet has exited the bore and pressure has dropped. The barrel will begin to move backward, driving the slide with it. This is where the various systems begin to differ.

The pivoting link system relies on a link that is pinned to the barrel on one end (but moves freely) and a pin in the frame in the other. When the barrel begins to move back, the pin will swing it downward, allowing the lugs on the top of the barrel and the lugs inside the slide to clear each other. The slide will continue rearward while the barrel is restrained by the link and pin.

The locking block system utilizes a locking block, which resides in the frame, and a lug that is integral to the barrel. The surfaces on the lug and the locking block are angled downward to drive the barrel down. When the barrel begins to move back, the barrel lug will cam against the locking block and be driven downward, allowing the lugs on the top of the barrel to clear the lugs of the slide. The slide will continue rearward while the barrel is trapped by the locking block.

The lug type system uses an integral lug on the bottom of the barrel to guide the barrel downward. A kidney-shaped track machined into the lug rides on a pin in the frame, guiding the barrel downward as it moves back. The slide will continue rearward while the barrel is trapped by the locking block.

The remainder of the cycling process for all three types is the same. As the slide continues rearward, it will extract and eject the empty case and cock the hammer/striker. On its forward stroke, the slide will strip a round from the magazine and feed it into the chamber. As the slide

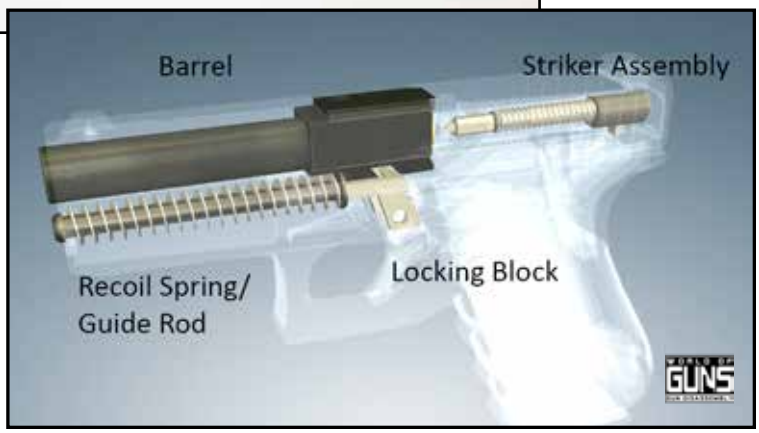


Figure 16a (top) & 16b:
Locking block-type tilting barrel action.

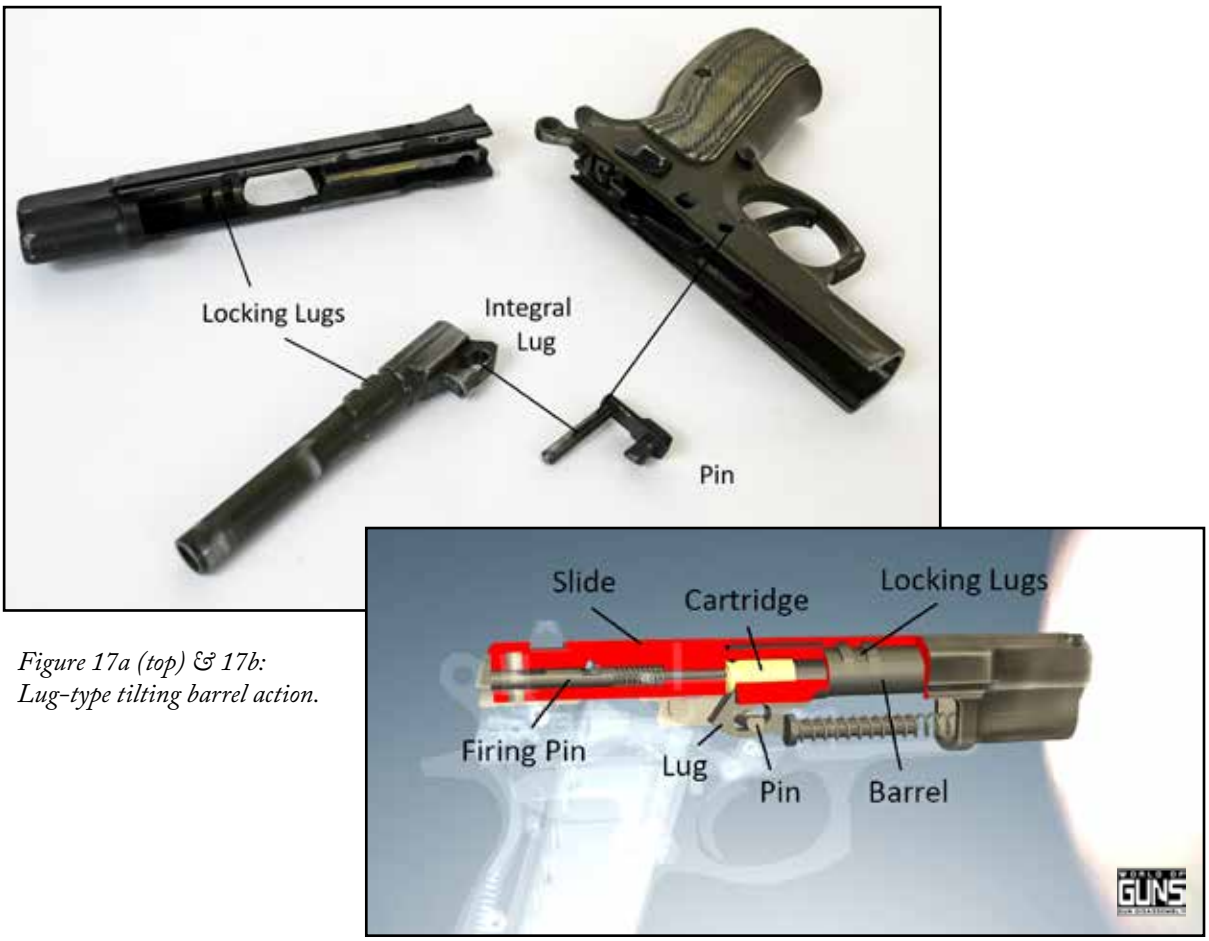


Figure 17a (top) & 17b: Lug-type tilting barrel action.

continues forward, it will contact the barrel and drive it forward and up along its respective device. The lugs on top of the barrel will engage the lugs inside of the slide, locking the chamber.

All three action types have found great success around the world with three of the most popular pistols. The 1911 pistol and its variants utilize the link-type action in calibers up to and beyond 10mm Auto. Glock pistols employ the locking block- and lug-style tilting barrel actions, while the CZ 75 uses the integral lug style. Several Glock models are available in 10mm, while the CZ can be found in 9x19mm Parabellum and .45 ACP.

Of all of the short recoil action types, the tilting barrel action is hands down the most popular. The majority of the large caliber semi-automatic pistols available today all employ the tilting barrel action. The design is so popular that it has been in constant use for more than 100 years, with over 74 years of service with the U.S. military.

› **Falling Locking Block/Inline** – The falling locking block/inline short recoil-style action is drastically different than the tilting barrel styles. While the tilting barrel action relies on the barrel's tilting action to lock and unlock the chamber, the falling locking block/inline action utilizes a specialized locking block that moves

Figure 18: Several tilting barrel, short recoil semi-automatic pistols.

(unlike the tilting barrel style, which is fixed) up and down while the barrel moves parallel to the bore's axis (straight, back and forth). The locking block moves up and down into lugs and reliefs on the barrel, frame, and slide. There are two basic styles of falling locking block/inline actions: the Walther system and the Bergmann system.

During discharge, the pressure inside the chamber will cause the locking surfaces to hold it closed until the bullet has exited the bore and pressure has dropped. The barrel will begin to move backward, driving the slide with it. This is where the various systems begin to differ.

The Walther system utilizes a pivoting locking block. A wedge-shaped locking block pivots on one end in a lug under the barrel and is driven by a plunger that lives in a lug on the chamber end of the barrel. The wedge has lugs that protrude outward that correspond to lugs in the slide.

The barrel and slide will move backward together a very short distance until the plunger bottoms out against the frame. Angled surfaces on the plunger and the locking block will drive the block downward into a recess in the frame, allowing the lugs to clear the slide. The barrel will be stopped by the locking block while the slide continues rearward.

The Bergmann-style action is much simpler. The Bergmann system relies on a locking block with a Y-shaped cross-section that fits around a collar on the barrel. There is a kidney-shaped track in the bottom of the Y

Figure 19: A Walther-style falling locking block/inline action.

block similar to the lug-type tilting barrel action that rides on a pin in the same manner. The block also has lugs that correspond to lugs on the slide.

The barrel and slide will move backward together a very short distance. The Y block will drop downward as the track in the bottom of the block is guided by the pin in the frame. The barrel will be stopped by the locking block while the slide continues rearward.

The remainder of the cycling process for both types is the same. As the slide continues rearward, it will extract and eject the empty case and cock the hammer/striker. On its forward stroke, the slide will strip a fresh round from the magazine and feed and seat it into the chamber.

As the slide continues forward on the Walther action, the slide will contact the barrel, driving the barrel forward. The locking block will be driven upward and wedge itself between the barrel and frame, locking the chamber. With the Bergmann action, the slide will drive the barrel forward, which drives the Y block. The track in the Y block forces the block upward, engaging the lugs of the block to the lugs on the slide and locking the chamber.

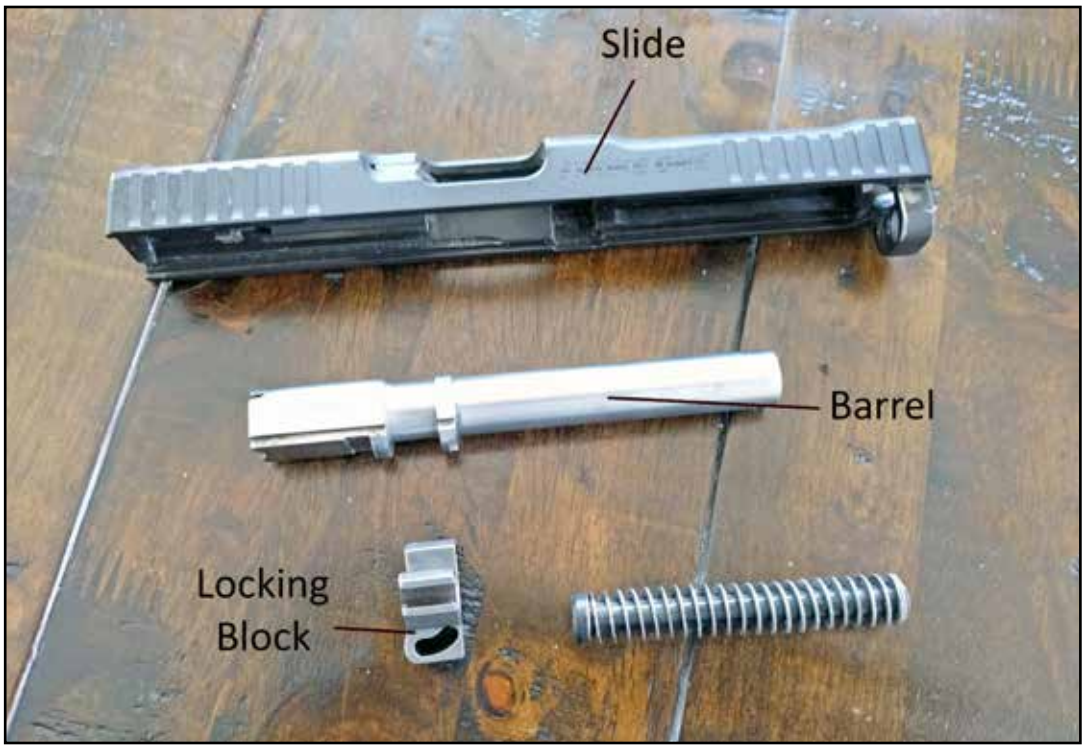


Figure 20: A Bergmann-style falling locking block/inline action.

Both system designs are fairly old, with the Bergmann system being over 100 years old and the Walther system being nearly 90. The pistols that employed these systems have become somewhat of a novelty. The Bergmann M1910/21 is a semi-automatic pistol chambered in 9x23mm Bergmann (9mm Largo) that began sales in 1910. The Walther P38 is a semi-automatic pistol chambered in 9x19 Parabellum that was designed in 1938.

Both systems have seen a revival with modern pistols and both have found military use. The Beretta 92 uses a Walther-style falling locking block action. The semi-automatic pistol chambered in 9x19mm NATO was adopted by the U.S. military, replacing the .45 caliber 1911. The Arsenal Firearms Strike One uses a Bergmann-style action. The Strike One is chambered in a variety of calibers, including 9x19mm NATO, and has found use with Russian Special Forces.

- **Rotating Barrel** – The rotating barrel short recoil action gets its name from the fact that the barrel will rotate to lock and unlock the chamber. The rotating barrel action is similar to the inline action in the fact that the barrel moves in line with the bore's axis but is different in the manner in which the chamber locks. The rotating barrel short recoil action chamber locks similarly to the bolt-action design.

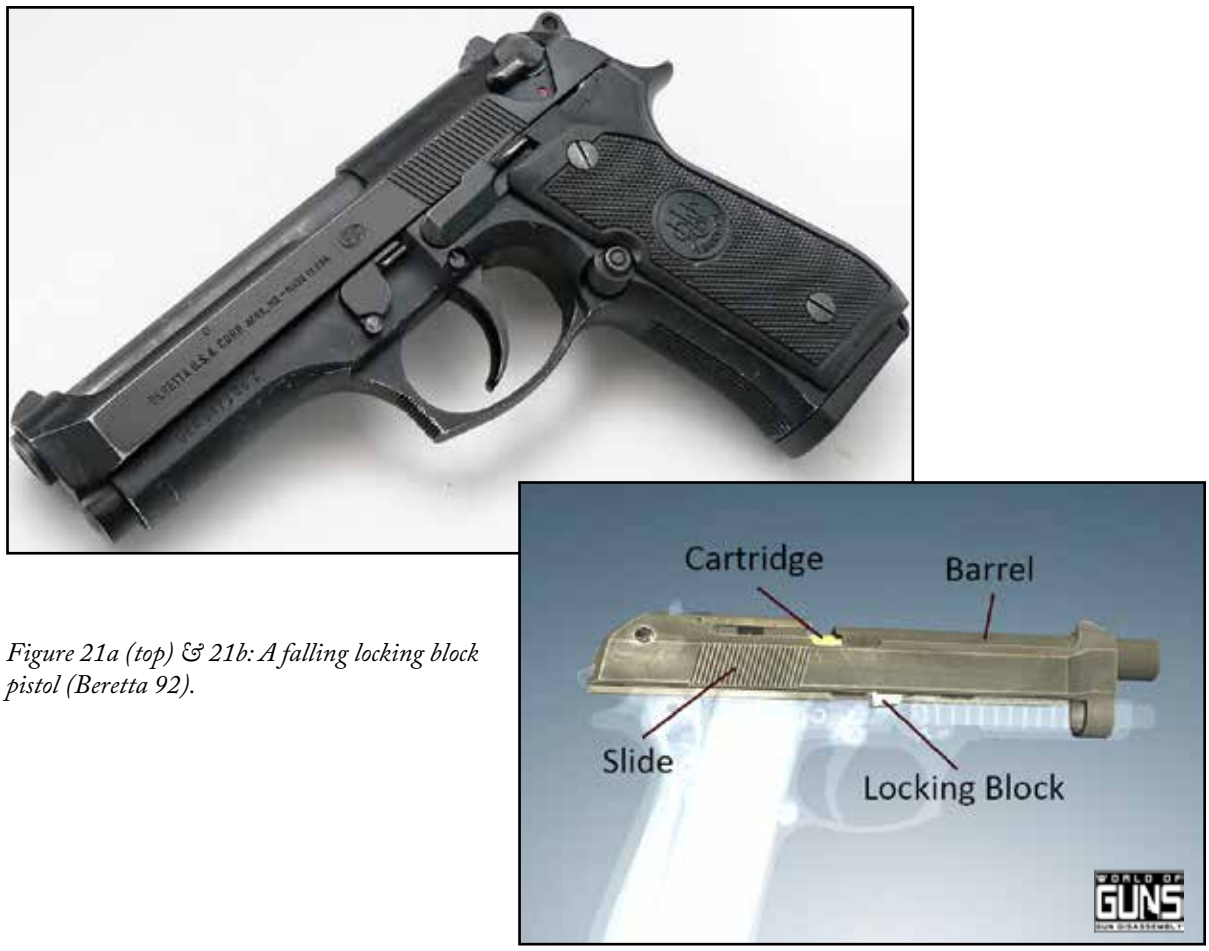


Figure 21a (top) & 21b: A falling locking block pistol (Beretta 92).

The rotating barrel action relies on a barrel with a helical track or channel machined into it and a lug located in the frame. The barrel also contains integral lugs that correspond with lugs in the slide. During discharge, the pressure inside the chamber will cause the locking surfaces to hold it closed until the bullet has exited the bore and pressure has dropped. The barrel will begin to move backward, driving the slide with it.

The lug on the frame cams against the channel of the barrel and forces it to rotate. As the barrel rotates, the lugs on the barrel and slide will move past each other, allowing the slide to continue to move rearward. As the slide continues rearward, it will extract and eject the empty case and cock the hammer/striker. On its forward stroke, the slide will strip a fresh round from the magazine and feed and seat it into the chamber. The slide will contact the barrel and drive it forward. The lug on the frame will force the barrel to rotate again, aligning the locking lugs and locking the chamber.

Like the falling locking block action, the rotating barrel action is very old, with models ranging from over 120 years old. The original patent on the rotating barrel lock-up system was awarded to John M. Browning

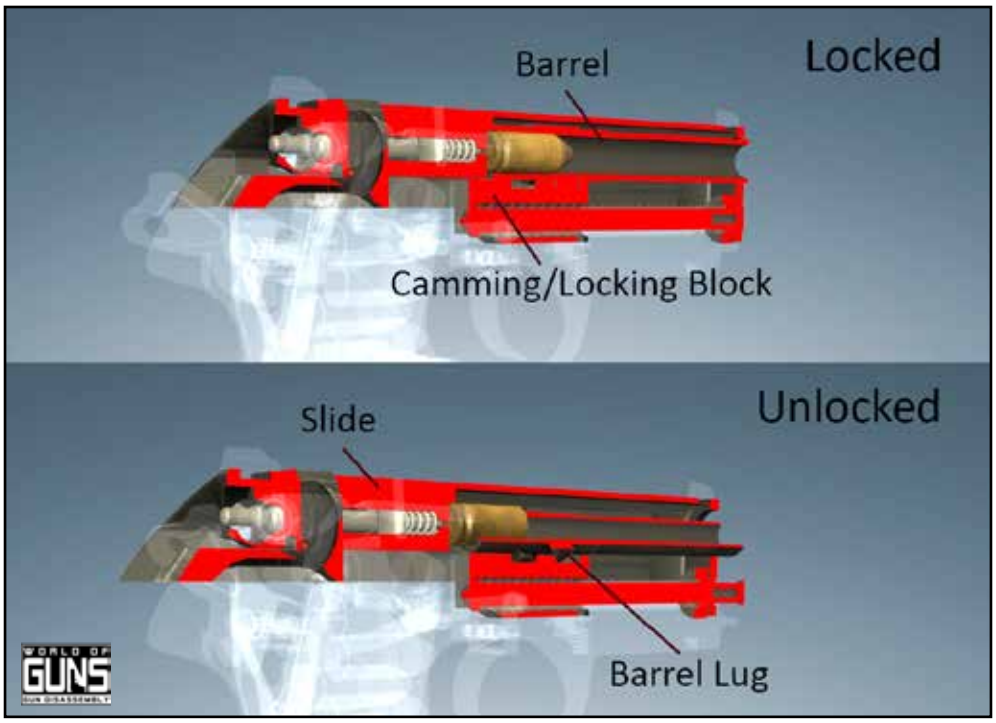


Figure 22: A rotating barrel short recoil action.

for the 1897 Rotating Barrel Pistol. In 1912, Steyr introduced the 1912, which used the rotating barrel system. Recently (2004), Beretta introduced the PX4 semi-automatic pistol (Figure 21), which utilizes the rotating barrel short recoil action.

Figure 23: A Beretta PX4 9mm pistol.

- **Roller Lock** – The roller lock short recoil action should not be confused with the roller delayed blowback action. Unlike the roller delayed blowback action, the roller lock action uses a locking breech design. The barrel of the roller lock design also moves inline.

  The roller lock short recoil action relies on a barrel, slide, locking piece, a tab on the frame, and rollers. The slide has recesses cut inside the rails that correspond with the rollers. The locking piece acts like a wedge, driving the rollers into these recesses.

  During discharge, the pressure inside the chamber will cause the locking surfaces to hold it closed until the bullet has exited the bore and pressure has dropped. The barrel and locking piece will begin to move backward, driving the slide with it. A tab on the frame will engage the locking piece

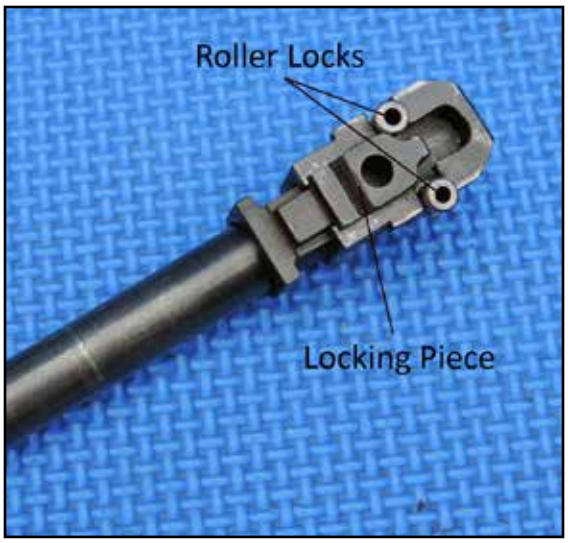


Figure 24: A roller lock short recoil action.

and restrain the barrel. As the slide moves rearward and the locking piece clears the rollers, the rollers will move inward, clearing the slide and allowing it to travel backward.

As the slide continues rearward, it will extract and eject the empty case and cock the hammer/striker. On its forward stroke, the slide will strip a fresh round from the magazine and feed and seat it into the chamber. The slide will contact the barrel and drive the barrel and locking piece forward. The locking piece will force the rollers outward into the recesses in the slide, locking the chamber.

The roller lock design is not as old as the other short recoil designs, but has found some military success. The CZ 52, designed in 1952, was used by the Czechoslovakian military and saw almost 30 years of service. The CZ 52 is a roller lock, short recoil semi-automatic pistol chambered in 7.62x25mm Tokarev.

- **Toggle Lock** – The toggle lock action, though similar, should not be confused with the toggle delayed blowback action. Unlike the blowback action, the toggle lock action uses a locked breech design. Much of the toggle's function through the cycling process is similar, with the only exceptions being the locking and unlocking of the breechblock and the recoiling barrel.

Figure 25: CZ 52 roller lock pistol.

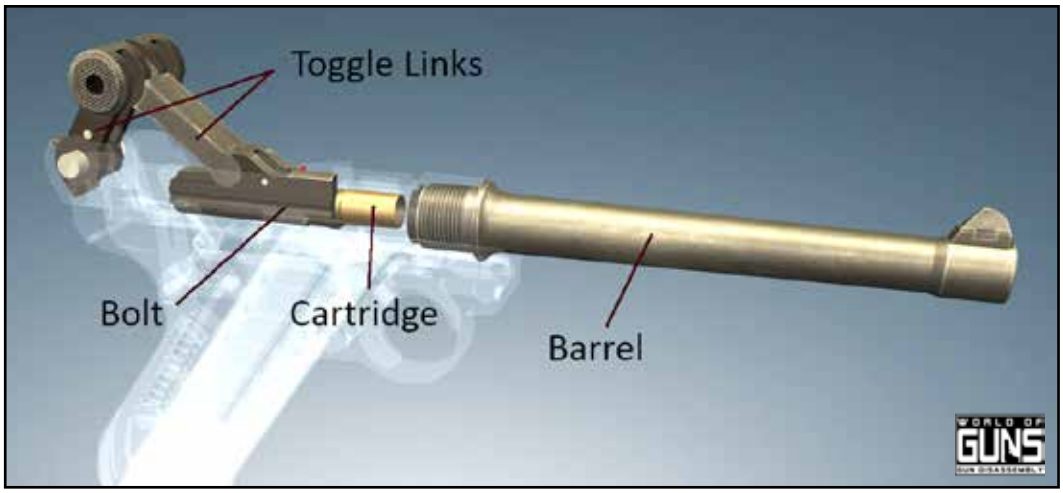


Figure 26: A toggle lock short recoil action.

The toggle lock action uses a multi-piece breechblock that is pinned together forming multiple hinge joints. The front of the assembly is the breechblock itself. The center piece is pinned to the block and end piece and is called the center toggle link. The opposite end of the breechblock is pinned to the frame and is called the rear toggle link. In the closed position, the pieces of the breechblock are parallel, in line with the bore. When the breech is completely open, the center and rear toggle links will turn upward, resting almost vertically.

During discharge, the pressure inside the chamber will cause the locking surfaces to hold it closed until the bullet has exited the bore and pressure has dropped. The barrel and breechblock will begin to move backward, driving the toggles with it. Because the toggle links are constrained from moving straight back, they begin to lift. The joint between the center and rear toggle links moves upward, allowing the breechblock to move backward.

- As the breechblock continues rearward, it will extract and eject the empty case and cock the striker. On its forward stroke, the breechblock will strip a fresh round from the magazine and feed and seat it into the chamber. The breechblock will contact the barrel and drive the barrel forward. When the breechblock has driven the barrel completely forward and the toggle is parallel to the barrel, the chamber is locked.

Figure 27: Luger P08 toggle lock pistol.

› The toggle lock action was first put into production in 1900, making it one of the oldest short recoil semi-automatic actions. The Luger P08 is a semi-automatic pistol that utilizes the toggle lock action designed in 1898 and produced in 1900. The Luger was originally introduced in 7.65x21mm Parabellum, but was later offered in 9x19mm Parabellum (Luger) and in a few very rare models in .45 ACP. Unlike other older action styles that have seen a recent rebirth with new models employing them, the toggle lock action has not faired the same results.

- **Inertia Operation** – The inertia operation action is unique to recoil operated actions. The inertia-operated action relies on both recoil energy and the inertia of the action parts. Like the long recoil action, the inertia-operated action is used exclusively with shotguns. The inertia operation action utilizes a two-piece bolt head/carrier design that collapses, and a fixed barrel. The bolt head and carrier are forced apart by a spring between them. Most modern inertia-operated systems also rely on a rotating bolt system similar to a bolt action to lock the breech. During discharge, the pressure inside the chamber will cause the locking surfaces to hold the breech closed until the bullet/shot has exited the bore and pressure has dropped. As the firearm begins to recoil, the inertia of the bolt carrier will cause it to remain stationary, as if it were fixed in position in space. The bolt head, moving with the recoiling firearm, compresses the spring between the bolt head and the carrier. Once the force of the spring becomes greater than the carrier's inertia, it will begin to drive the carrier rearward at a greater velocity than the bolt. A slot in the bolt carrier will guide a cam pin attached to the bolt and force it to rotate, unlocking the chamber. As the bolt body continues rearward, it will pull the bolt head with it, which also extracts and ejects the empty case and cocks the hammer. On its forward stroke, the bolt

Figure 28: An inertia-operated action.

Figure 29: A Benelli inertia-operated shotgun.

head will strip a fresh round from the elevator/shell lifter and feed and seat it into the chamber. The bolt head will bottom out against the breech face of the barrel as the carrier continues forward, forcing the bolt to rotate and lock the chamber.

- The inertia operation action is another very old design, with patents being awarded around 1900. The first firearm to utilize the inertia-operated action was the Sjögren shotgun designed by Carl Axel Theodor Sjögren. The design fell out of favor for over 70 years until Benelli adopted a similar inertia-style action for its shotguns and others licensed by them. In 2012, the Browning Arms Company introduced the A5, an inertia (Kinematic Drive) operated shotgun that pays homage to the company's long recoil-operated Auto 5.

Gas-Operated

The gas-operated action is unlike the blowback or recoil-operated semi-automatic actions in the respect that the energy that drives the action does not come from the cartridge itself or the energy from discharge. The gas-operated action (Figure 1) relies on the expanding gas from the cartridge being discharged to act upon the action's parts. A small amount of gas is tapped from the bore just ahead of the chamber or farther down the barrel. The gas operation style action is used with pistols, rifles, and shotguns. With an empty and locked action, the cycle of operations for a semi-automatic gas operation style action firearm is as follows:

- Depending on specific model, the firearm is loaded, either directly into an internal fixed magazine or through a removable magazine. (1)
- The operator must manipulate the action by means of charging handle or slide. The charging handle/slide is pulled to the rear of the firearm, opening the chamber and unlocking the breech and cocking the hammer/striker. At the same time, a fresh cartridge has been automatically fed, in line with the bolt/slide. (2)
- The action spring will drive the bolt/slide forward, stripping a round from the magazine and driving it into the chamber. Depending on the specific recoil action being employed, the chamber may lock in various ways. Lugs on the bolt/slide and receiver are common means of locking the chamber. (3)
- The trigger is pressed, releasing the hammer/striker and discharging the round. (4)
- As the pressure builds inside the cartridge, the case will begin to swell and seal the chamber. The bullet will be forced from the case, into the chamber's throat and into the bore. As the bullet travels through the bore, it will pass the gas port. Some of the high pressure gas acting upon the bullet will be diverted by a port in the barrel. Depending on the model, the gas will act upon a piston, which acts upon a bolt carrier or directly against a bolt carrier. The gas will drive the piston/carrier rearward. The piston/carrier's rearward movement will unlock the bolt. Depending on the model, the bolt may unlock in various manners. (5)
- As the carrier moves rearward, it will move the bolt with it. As the bolt/carrier moves back, the bolt will strip the empty case from the chamber and eject it. The carrier will also cock the hammer/striker. (6)
- Again, the action spring will drive the bolt/slide forward, stripping a round from the magazine and driving it into the chamber. The chamber will once again lock. (7)
- If the trigger is still being pressed, it must be released to the reset position in order to fire the next round. If the trigger was already reset, it can be pressed again to fire the next round. (8)

The gas-operated action has grown into the preferred semi-automatic action for military, police, hunters, competitors, and civilians. The gas-operated action style is praised for its reliability, durability, rate of fire, and in many cases, accuracy and precision. The gas-operated action is also praised for its versatility.

Unlike the blowback and recoil-operated actions, which are susceptible to malfunctions caused by under- or overpowered ammunition, the gas-operated action tends not to be as susceptible. A majority of the gas-operated actions are tuned to work with a variety of ammunition types through port size and location, variable

Figure 1: Gas-operated action cycle of operations.

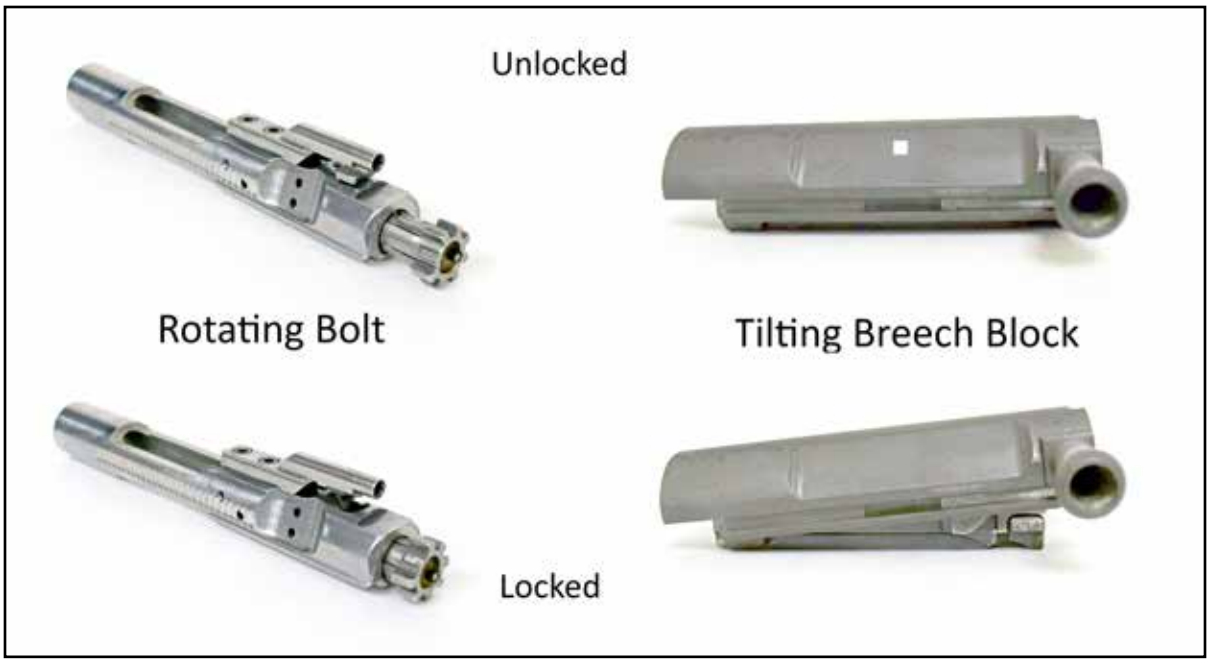


Figure 2: Tilting breechblock versus rotating bolt.

gas blocks, and "bleed off" valves or ports. This means that the action will utilize just enough gas pressure to cycle the action and bleed off any residual gasses.

Gas-operated actions rely on two basic methods of locking the breech: tilting breechblock and rotating bolt. The tilting breechblock system utilizes a two-piece bolt/carrier design. The breechblock of the tilting system is controlled by the movement of the carrier. When the breech locks, the breechblock will drop into a recess in the receiver and the carrier will move over the top, locking the breechblock into the chamber. When the breech unlocks, the carrier will move backward, lifting the breechblock out of the recess and back, guided by rails in the receiver.

The rotating bolt system operates similarly to the bolt-style action in the respect that the bolt will rotate to lock and unlock the action. The rotating bolt system utilizes a multi-piece bolt/carrier system and some type of camming surfaces. When the breech locks, the bolt will rotate so that the lugs of the bolt will align with the lugs on the barrel extension/receiver. A camming lug on the bolt will ride inside a channel on the carrier that forces the bolt to rotate. When the breech unlocks, the carrier will move backward, forcing the bolt to rotate and the lugs to clear each other.

Both systems have been employed successfully with various militaries around the world. The tilting breechblock system has been employed by many famous firearms including the FN FAL and its variants, as well as the VZ 52 rifle and the SKS. The rotating bolt system boasts a more impressive line of firearms, including the AR-15/10/LR-308 family of firearms, the AK-47 and all of its variants, and the FN SCAR line of firearms.

Gas-operated firearms are some of the most common action types used with modern day semi-automatic rifles and shotguns. The action has gained so much success because of its achievements on the battlefield with different models. The three major types of gas-operated actions are long and short stroke piston and direct impingement.

- **Long Stroke Piston** – The long and short stroke piston systems are so named because of the distance of the piston's travel. Typically, with a long stroke piston system the piston is attached to the bolt carrier. When the gun is fired, the high pressure gas that has been tapped by the gas port acts upon the piston, driving the piston/carrier/bolt assembly rearward. The long stroke piston system gets its name from the fact that the piston and carrier move together as a single unit throughout the entire travel of the action's stroke.

  The piston of the long stroke piston system is often quite long, averaging around 6 in. The bolt/carrier assembly is also often fairly heavy compared to other systems because of the added weight of the piston and the piston housing. The weight of the bolt/carrier makes for a very robust system, which requires a greater amount of gas pressure to reliably move the action. The weight of the system also aids in feeding, chambering, and locking. The increased weight equates to more momentum to strip the round from the magazine and drive it into the chamber.

  The AK-47 is undoubtedly one of the world's most battle-proven, reliable, and toughest firearms ever, being fielded in every major and minor war or conflict since its introduction in 1947. Much of the AK-47's success is contributed to the long stroke operating system. There is also a large array of variants in calibers from 5.45x39 to 7.62x51 NATO that all use the long stroke piston system. The M1 Garand, IWI Tavor, and the M249 Squad Automatic Weapon (SAW) all use a long stroke piston system. There

Figure 3a : Long stroke piston system.

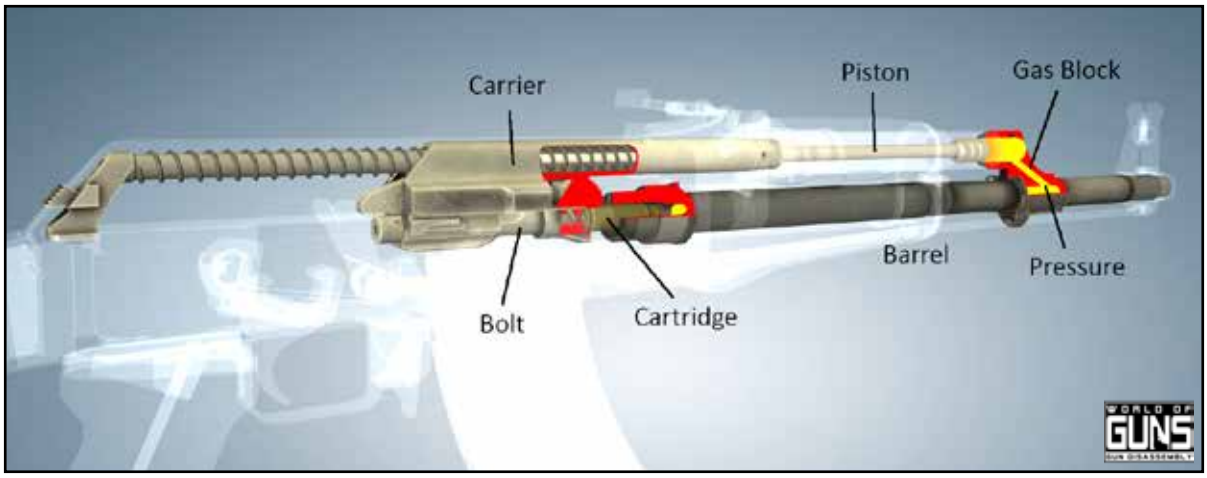


Figure 3b : Long stroke piston system.

are even variants of the AR-15 (which uses a direct impingement system) from Primary Weapon Systems (PWS) that utilize a long stroke piston action.

- **Short Stroke Piston** – The short stroke piston system operates in a similar manner to the long stroke system with a few minor exceptions. Unlike the long stroke system, where the piston is fairly long and travels the length of the action's stroke, the short stroke system uses a shorter piston that is a separate piece than the carrier. When the system cycles, the piston only moves a small distance compared to the bolt/carrier, which travels the full length of the cycle's stroke.

  The short stroke piston system is also known as the "tappet" system. A tappet is a mechanism that imparts a linear motion to another component within a machine. In the case of the short stroke piston system, the piston is often referred to as a tappet. Depending on make and model, there may also be an "operating rod" that lives between the piston and the bolt carrier.

  During discharge, high pressure gas acts upon the piston, driving it rearward. Depending on the specific model, the piston may act upon the carrier directly or against an operating rod that acts upon the carrier. The piston will only move a very short distance, but will impact the carrier/operating rod with enough force to create sufficient momentum in the bolt/carrier to overcome the resistance of the action/recoil spring. Often the piston and operating rod are spring-loaded, which will push them back into their resting position until the firearm is discharged again.

  Although the short stroke piston system may seem more complicated than the long stroke system (because of the increased amount of parts), the short stroke system has the advantage of being lighter than the long stroke system. Because the piston is a separate piece than the carrier, the carrier assembly can be lighter, as it does not require a provision for the piston. This means the short recoil system requires less energy to cycle the action, which translates to less recoil. The design of the system has a built-in flaw in the form of the operating rod, which is often fairly thin and prone to bending/breaking.

Figure 4: Short stroke piston system.

There is a huge array of short stroke piston-operated firearms with many very notable military service weapons. The FN SCAR series of firearms and many AR-15 variants utilize a short stroke piston system, which only uses a piston to drive the action. The VZ 52 rifle and the SKS rely on short stroke actions that use a piston and an operating rod.

- **Direct Impingement** – The direct impingement system differs from both of the piston systems in the fact that there is no piston involved. With a direct impingement system, the carrier itself is moved directly by the gasses from the cartridge. The movement of the carrier will facilitate the breech locking and unlocking.

During discharge, the high pressure gas that is tapped by the gas port is directed through a gas block and into a gas tube that leads to the carrier. The gas drives the carrier rearward, which unlocks the bolt/breechblock and completes the cycle of operations. Any residual gas is vented into and out of the receiver.

Of the three gas-operated actions, the direct impingement system tends to be the most susceptible. The whole system must be "tuned" to ensure proper function. This means that the diameter of the gas port and its location from the chamber are critical to ensuring that there is enough volume of the correct pressure gas. The highest pressures are generated near the chamber, so placing a specifically sized gas port farther down the barrel will tap gases

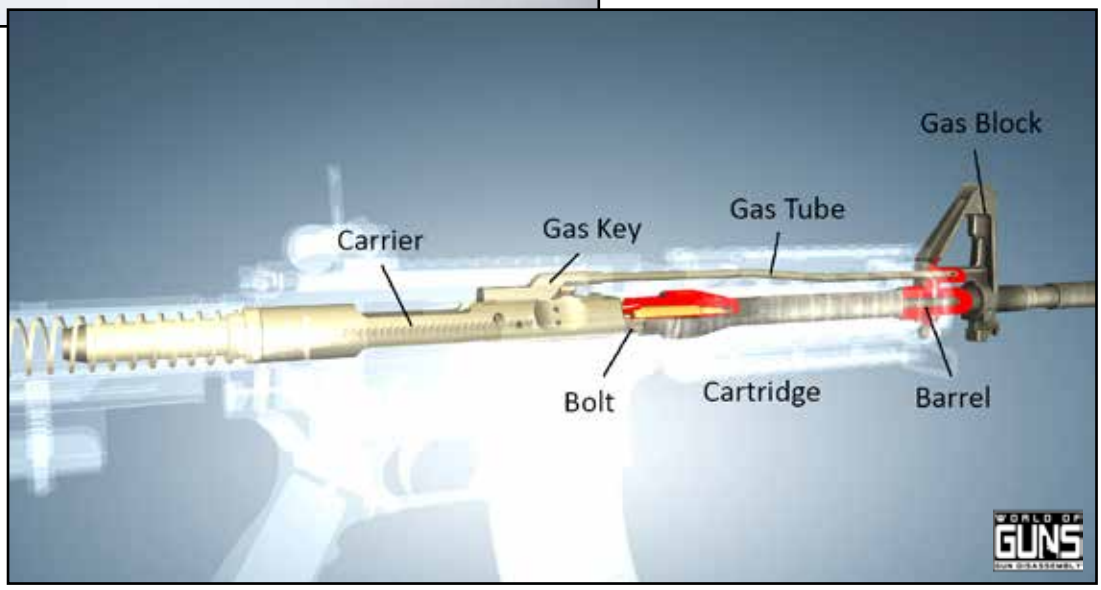


Figure 5a (top) & Figure 5b: Direct impingement system.

that are a lower pressure. This ensures the action will not face any unneeded wear from over-pressurization. The system also relies on the length of the barrel ahead of the gas port for "dwell time."

Dwell time is the length of time the gas system stays pressurized. Dwell begins when the bullet passes the gas port and the system begins to pressurize and ends when the bullet exits the muzzle and the system is "uncorked." The longer the distance from gas port to muzzle, the longer the system stays pressurized, ensuring there is enough gas to properly cycle the action. Dwell is not really a concern for the two piston-driven action types because of the operation of the piston and the often oversized gas port. Both piston systems tend to be overly pressurized at the gas port, which typically is bled off once the piston has moved a short distance.

The direct impingement system is also heavily affected by ammunition and maintenance. Because the system relies directly on the amount of pressure that is generated by the cartridge, variances from round to round can affect the way the system cycles. Underpowered or overpowered ammunition can cause the system to malfunction.

Also, because the system relies directly on the gasses from the cartridge, the whole system is exposed to carbon buildup and fouling from unburnt propellant. The gas port, block, tube, carrier, bolt, receiver and fire control group, and any other parts that are exposed internally where the gas is directed are all susceptible to this type of fouling. Extra care must be taken with the direct impingement system, making regular cleaning a habit.

Although the direct impingement system may seem like it has a malignant flaw, the system has been employed successfully by one of the world's most recognized firearms, the AR-15/M16. The direct impingement system was first used in production with the MAS-49 rifle in the early '40s and into the late '70s by the French army. In the late '50s, Eugene Stoner incorporated the direct impingement system into the AR-10 and later into the M16/AR-15. Now, the direct impingement system is used with huge numbers of AR-platform firearms from many different manufacturers around the world.

Powered Guns/ Gatling and Chain Operation

The Gatling and chain-type operations vary greatly from previous actions that have been discussed. First, the Gatling and chain-type operations are typically restricted for large caliber, mounted machine guns. Second, both actions do not rely on either recoil energy or gas pressure to cycle the action; they are both cycled by an external mechanical means. Third, both systems are typically belt-fed, or fed by a very large capacity magazine.

GATLING OPERATION

The Gatling-style operation is one of the oldest repeating/self-loading action types. The Gatling-style action was patented in 1862 by Dr. Richard J. Gatling and is still in use today in a similar form. The original Gatling gun was hand-driven via crank but was later equipped with an external drive.

The Gatling system utilizes multiple barrels (6 – 10), a carrier and a lock cylinder that all revolve around a centralized shaft. These individual parts rotate while being in a fixed position to each other (the same barrel, groove of the carrier, and position of the lock cylinder stay aligned). When the crank is driven, the shaft rotates, spinning the barrels, carrier, and lock cylinder with it. The carrier is grooved around its circumference to accommodate cartridges, while the locking cylinder has reliefs around its face to accommodate the cartridge heads. As the shaft spins, it activates linkage that forces the locking cylinder to reciprocate (move back and forth), locking and unlocking the chamber via locking surfaces on the lock cylinder and the barrels. Cartridges are fed from the side or above by various means (hopper, drum, magazine, belt) and a single round will fall down into the first groove of the carrier.

Following is an example of the cycle of operations for a Gatling-style action (Figure 6) with six barrels and an empty breech. For the purpose of this example we will assume the action is a top feed system that rotates clockwise and call the barrel in the 12 o'clock position Barrel 1. The other barrels are numbered sequentially, counterclockwise (behind the gun).

- Rounds are fed into the top of the action by some means. The crank is rotated, dropping single rounds into the groove of the carrier aligned with Barrel 1. Simultaneously, the lock cylinder moves back. (1)
- The crank is rotated, moving the system clockwise and bringing Barrel 2 into the 12 o'clock position. Simultaneously, a round drops down into the second groove of the carrier and the lock cylinder moves forward and the fire control group is cocked. The first barrel is now roughly in the 2 o'clock position with a round locked in the chamber. (2)
- The crank continues to rotate, moving the lock cylinder back once more, and moves the third barrel into the 12 o'clock position and drops a cartridge into the third groove of the carrier. The crank continues around, moving the lock cylinder forward while simultaneously the first barrel moves roughly into the 4 o'clock position, where a trip releases the firing piece and fires Barrel 1 while Barrel 2 is moved to the 2 o'clock position and locked. (3)
- The crank continues to rotate, moving the lock cylinder back once more and extracting the empty case with it. The barrel moves into the 12 o'clock position and a cartridge drops into the fourth groove of the carrier. The crank continues around, moving the lock cylinder forward while simultaneously the first

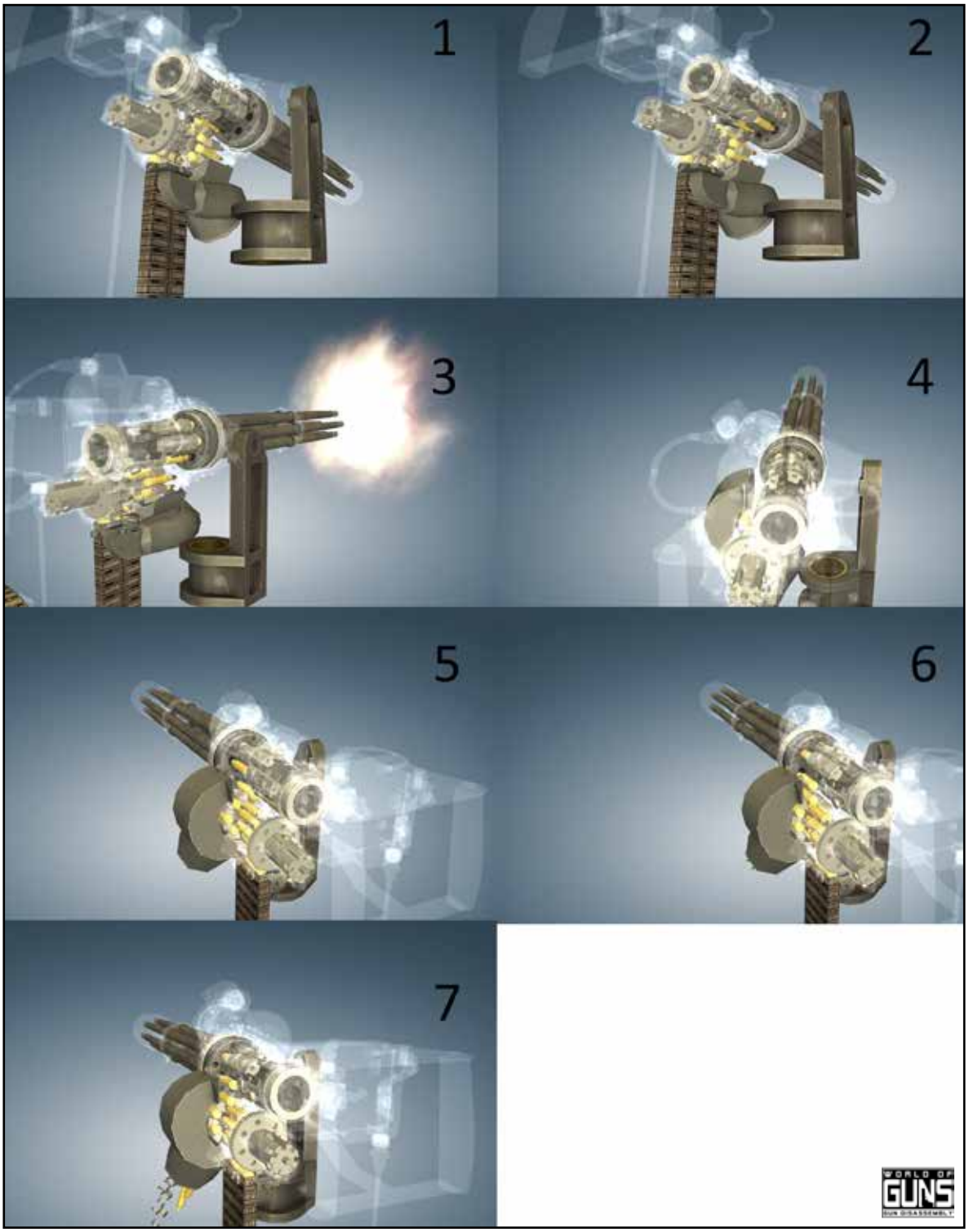


Figure 6: Gatling operation cycle of operations.

barrel moves roughly into the 6 o'clock position. The empty case is kicked out of the bottom of the action and the second barrel has moved to the 4 o'clock position and fired. The third barrel has moved to the 2 o'clock position. (4)

- The crank continues to rotate, moving the lock cylinder back once more and extracting the empty case with it. The fifth barrel moves into the 12 o'clock position and a cartridge drops into the fifth groove of the carrier. The crank continues around, moving the lock cylinder forward while simultaneously the second barrel moves roughly into the 6 o'clock position. The empty case is kicked out of the bottom of the action and the third barrel has moved to the 4 o'clock position and fired. The fourth barrel has moved to the 2 o'clock position. The first barrel has moved to the 8 o'clock position, where nothing happens. (5)
- The crank continues to rotate, moving the lock cylinder back once more and extracting the empty case with it. The sixth barrel moves into the 12 o'clock position and a cartridge drops into the sixth groove of the carrier. The crank continues around, moving the lock cylinder forward while simultaneously the third barrel moves roughly into the 6 o 'clock position. The empty case is kicked out of the bottom of the action and the fourth barrel has moved to the 4 o'clock position and fired. The fifth barrel has moved to the 2 o'clock position. The first barrel has moved to the 10 o'clock position and the second barrel has moved to the 8 o'clock position, where nothing happens. (6)
- The crank continues to rotate, moving the lock cylinder back once more and extracting the empty case with it. The first barrel moves back into the 12 o'clock position and a cartridge drops into the first groove of the carrier again. The crank continues around, moving the lock cylinder forward while simultaneously the fourth barrel moves roughly into the 6 o'clock position. The empty case is kicked out of the bottom of the action and the fifth barrel has moved to the 4 o'clock position and fired. The sixth barrel has moved to the 2 o'clock position. The second barrel has moved to the 10 o'clock position and the third barrel has moved to the 8 o'clock position, where nothing happens. (7)

The system will continue through this cycle until the crank has stopped moving or the firearm has run out of ammunition. Outside of the main parts (barrels, carrier, lock cylinder, shaft and crank), the system utilizes a series of linkage, cams and other actuators to ensure proper function. The system is also heavily dependent on the timing of all of the parts, but this ensures reliability with a high rate of fire.

Modern Gatling designs have replaced the hand crank with an electric motor. The system is actuated by a button that causes the motor to spin the shaft and the system to cycle. The modern Gatling design is referred to as a "minigun" as it is capable of an insane rate of fire. While most crank-driven designs can achieve a rate of fire around 350 – 600 rpm, the modern minigun is capable of 3,000 – 6,600 rpm with cartridges as large as the 20 x 102mm. The modern design also uses belt or link side-feed (typically right) and side-eject (typically left). The system typically rotates counterclockwise with the firing position moving to the 12 o'clock position. The modern system has also done away with the lock cylinder in favor of individual bolts for each barrel. This allows each bolt to move independently of the others in different stages of the cycle.

The Gatling design has gained so much popularity because of its many advantages. The main advantage to the Gatling system is the capability of very high rates of fire without excessive heat and wear on the barrels/action. For example, if the gun featured six barrels and had a rate of fire around 3,000, each barrel would only fire around 500 rpm. This figure for each barrel

is much lower than other fixed barrel machine guns, which average between 650 and 800 rpm.

The Gatling design has seen constant military use around the world since its introduction in the 1860s. Its first use was during the American Civil War and in every major war since. The original crank-driven design even found much use with the U.S. Military up until the early 20th century. The design fell out of favor to gas- and recoil-operated designs with the U.S. Military but was still used continually other places around the world. The design was reintroduced to the U.S. Military after WWII by General Electric with an aircraft-mounted weapon called the M61 Vulcan and later a scaled-down, more portable version called the M134. By the mid '80s, the design fell out of favor because the availability of spare parts for the M134 had dwindled and many of the units were out of service. The design was given life once more in the early 2000s by Dillon Aero, with a completely new design called the M134D.

While external drive (electric motor/pneumatic) Gatling designs are strictly considered machine guns (Class III) by the ATF, hand crank-driven designs are considered rifles and are not subject to the same paperwork and fees. A crank-driven Gatling gun can be transferred to any person the same way a rifle could. The ATF does not consider the hand-cranked design an NFA item because the operator must still manually manipulate the crank to complete the firing sequence. If the operator was to stop moving the crank, the gun would stop immediately.

CHAIN OPERATION

The chain-type operation is another example of an externally powered gun. The chain operation works in a similar manner to other autoloaders in the respect that the system only uses one barrel and the bolt assembly moves in line with the bore's axis, but that's where the similarities end. The chain-type action operates more like a bicycle than a traditional firearm.

In the heart of the chain-type action is the roller chain drive. The system utilizes the roller chain, sprockets, a shoe, gears, tabs, cams and other actuators to complete the cycle of operations. The four main sprockets are laid out in a rectangular pattern, forcing the chain to complete a rectangular loop. One of the sprockets is driven by an electric motor, which moves the chain and forces the cycle of operations. There is also

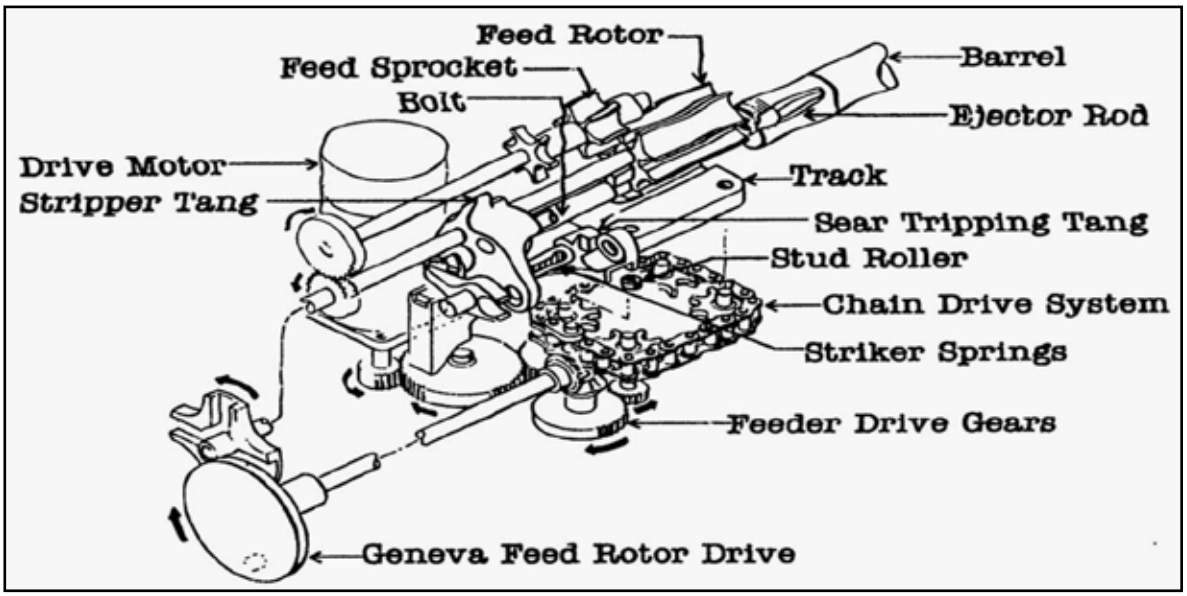


Figure 7: The chain operation cycle of operations.

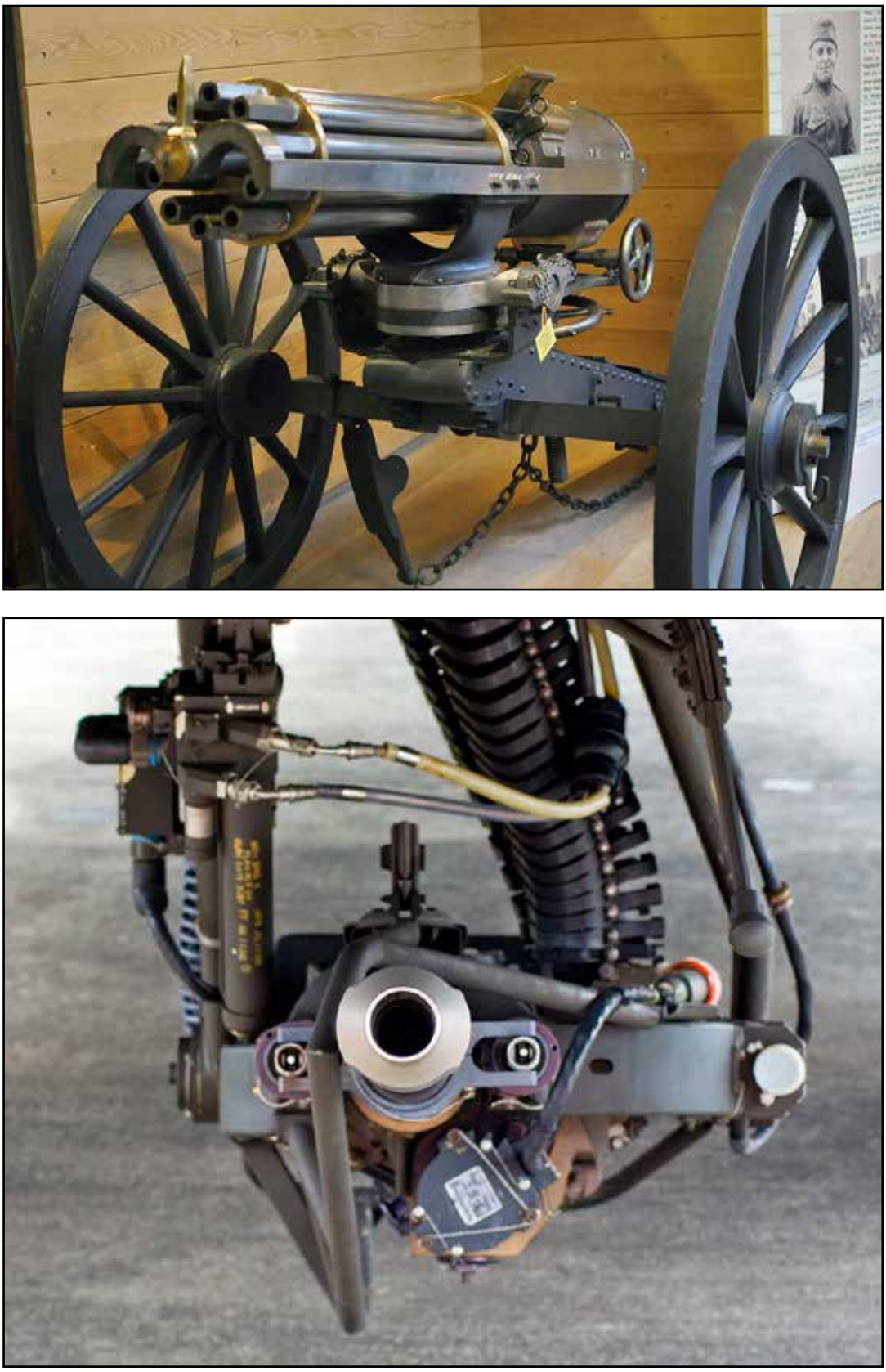


Figure 8: A Gatling and a chain gun (bottom).

another specialty sprocket inside the action that is used to feed and extract rounds called the feed sprocket. The feed sprocket features special T-shaped protrusions that are used to grab and move the cartridges and empty cases. The cycle of operations for a chain operation action with an empty breech is as follows:

- The bolt is closed and the breech is locked. As the motor begins to drive the sprocket and chain, the shoe on the chain will move backward (toward the rear of the receiver) and will grab the bolt/carrier assembly and drive it backward. Simultaneously, the feed sprocket will rotate and grab a fresh round from the feed source and move it in line with the chamber.

- As the motor spins, the chain will continue through its loop, driving the shoe with it. The shoe will continue to travel through its loops, moving around the rear of the receiver until reaching the opposite side as the shoe is moving forward (toward the front of the receiver).

- The chain/shoe continues forward, grabbing the bolt/carrier. The chain/shoe drives the bolt/carrier into the new cartridge and forces it into the chamber. As the chain continues forward, the bolt head will collapse and rotate in the carrier, locking the chamber.

- As the chain/shoe reaches its forward-most position (before rounding the corner to pass the front of the receiver), the shoe activates the cocking piece.

- As the chain/shoe continues around the front of the receiver, the shoe will contact the firing tab, which will release the firing piece and fire the system. Because the system does not use any energy from the cartridge, all of the pressure from the discharging cartridge will leave through the gun's muzzle.

- The chain will continue through its loop. The shoe has once again moved to the side of the receiver and is moving backward again. The shoe will contact the bolt carrier and drive it rearward, extracting the empty case from the chamber. As the shoe continues rearward, the feed sprocket will rotate, moving the empty case out of the receiver (ejecting) and bringing a fresh round in line for feeding.

The loop will continue until the trigger is released or the system runs out of ammunition. The major advantage of the chain design is its capability to control rate of fire. The system is capable of firing any number of rounds from 1 to around 550 rpm. This allows very precise application of fire, unlike the Gatling design, which is fixed in its rate of fire.

The chain design is fairly new compared to other actions and has not seen any use with civilian firearms. The chain design has only been employed with military weapons, including the M242 25mm auto cannon. The design was later scaled down to a vehicle-mounted weapon chambered in 7.62x51 NATO called the Hughes EX-34.

The advantage to these two types of systems is that because they do not rely on the energy from the discharging cartridge, they are not susceptible to the type of malfunctions other systems are. With these systems, if a cartridge fails to fire, the external mechanical system will just extract, eject, and load a fresh cartridge. This creates an extremely reliable action that is capable of very high rates of fire.

Open or Closed Bolt Operation

While every action we have previously discussed works on what is known as "closed bolt" operation, there are some types of firearms that work from the "open bolt" positon. Closed bolt operation simply means that the bolt/breech block/slide is locked against the chamber and the breech is fully closed when the trigger is pressed. The closed bolt design is employed by every major action type including all the manual actions, a majority of the autoloading actions, and a very large percentage of select fire weapons and machine guns.

The open bolt style of operation functions exactly opposite of the closed bolt design. The open bolt style of operation employs a system where the bolt/breech block/slide is locked in the open position when the trigger is pressed. Pressing the trigger releases the bolt lock and allows the bolt to move forward, stripping a round from the magazine and driving it into the chamber and locking. As the bolt locks, the fire control group will be activated, firing the round.

One of the major benefits of the open bolt design is found with automatic weapons with high rates of fire. Continuous fire will heat the barrel and chamber until the point of "cook off." Cook off is a condition where the cartridge in the chamber spontaneously ignites from reaching its autoignition temperature. With the open bolt design, there is no cartridge in the chamber when the action is set in the firing position. This prevents a round from "cooking off" while resting in the chamber between shot strings. The open bolt design also has the benefit of allowing air to flow through the action and barrel to aid in cooling. With a closed bolt design, air is only capable of entering the muzzle, but with an open bolt design, air can enter through the muzzle and through the action, aiding in faster cooling.

One major drawback to the open bolt design is its lack of accuracy and precision for the first couple of rounds fired. With a closed bolt design, only the trigger, linkage and the hammer/striker move right before the point of ignition. This happens within milliseconds, which does not permit much, if any, disruption from the action or operator and allows the operator to hold the firearm more steadily during discharge. With the open bolt design, the entire bolt/carrier plus the fire control group all move. When the bolt slams forward, it creates a great disruption in the firearm.

Figure 1: Closed versus open bolt operation.

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Fire Control Group and Trigger Operations

Now that you have a basic understanding of the different firearm types and the actions that drive them, you can dive a bit deeper into the "ignition" systems of these machines. There are two systems used and multiple ways these systems can function. These systems are not limited to one firearm or action type and can be found across the spectrum of firearms found across the world.

HAMMER- OR STRIKER-FIRED

There are two basic systems used to create ignition in the cartridge's primer: hammer and striker. These two systems can be found in various firearm types and in many different actions. Both systems perform the same function, but in very different ways.

The hammer-fired system is so named because its action is similar to a hammer hammering a nail, with the only exception being the firing pin. A part called the hammer is used to strike a part called the firing pin, which in turn strikes the primer. And there are two ways the system can operate.

First, when the trigger is pressed, the trigger itself will directly act upon the hammer, releasing it and causing ignition (like with an AR-15 fire control group). Second, when the trigger is pressed, the trigger will act upon a linkage, or sear, which acts upon the hammer. The 1911 uses a design similar to this.

Typically, the fire control group lives in the frame/receiver of the firearm and the firing pin lives in the bolt/breechblock/slide. Both the hammer and the trigger pivot on pins in the frame/receiver. When the trigger releases the hammer, the hammer will pivot around its pin under spring force. The weight and speed of the hammer is critical to proper ignition without damage to the primer.

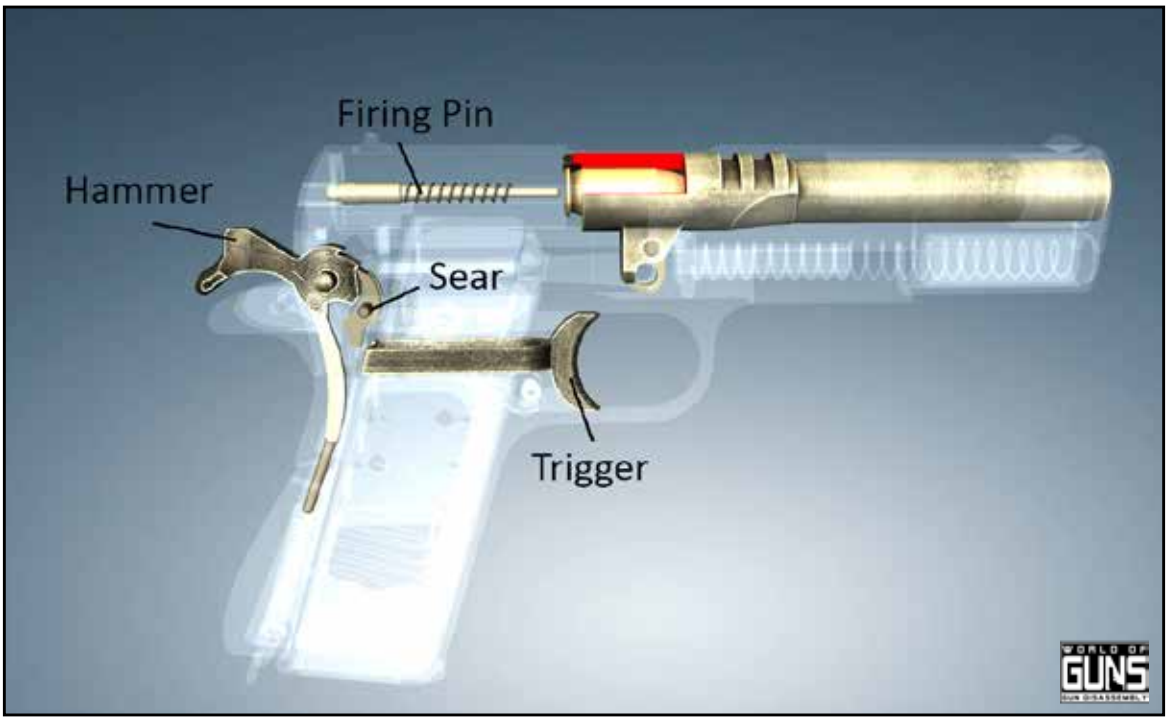

Figure 2: A hammer-fired system.

The firing pin is housed separately from the rest of the fire control group and may be one of two types: floating or sprung. Floating firing pins move freely within their respective housing. The weight of the floating pin is critical in semi-automatic and automatic firearms because the momentum of the pin will carry the pin forward during the feeding and locking stages of the cycle of operations. You will notice that with some floating firing pin designs there are small indentations on the primers of loaded rounds that were not fired. The floating firing pin design has the potential to cause a malfunction called a slam fire. A slam fire occurs when the firing pin becomes wedged in the forward position and the bolt/slide closes on a live round.

The sprung firing pin was designed to prevent this issue. A light power spring is used to hold the firing pin rearward. When the hammer strikes the firing pin, the energy delivered overpowers the firing pin spring, driving the firing pin forward and causing ignition. Once the action cycles, the spring will force the firing pin rearward once more.

There is also another type of hammer-fired system known as the "hammerless" or "hidden hammer." The hammerless or hidden hammer action still utilizes a hammer like a regular hammer-fired system, but the hammer is concealed within the firearm's frame. While the hammer of a regular hammer-fired system can be manipulated by the operator, the hammerless design restricts the operator from manually cocking the hammer. The enclosed hammer prevents snagging on clothing or other garments.

The striker-fired system is more simplistic. The striker-fired system relies on a part called the striker to create ignition. The striker acts like a spring-loaded firing pin.

Like the hammer-fired system, the striker-fired system can work in one of two ways. First, when the trigger is pressed, the trigger itself will directly act upon the striker, releasing it and causing ignition (like with many bolt-action rifles). Second, when the trigger is pressed, the trigger will act upon a transfer bar, or sear, which acts upon the striker. Many polymer, semi-automatic pistol systems use this type of action.

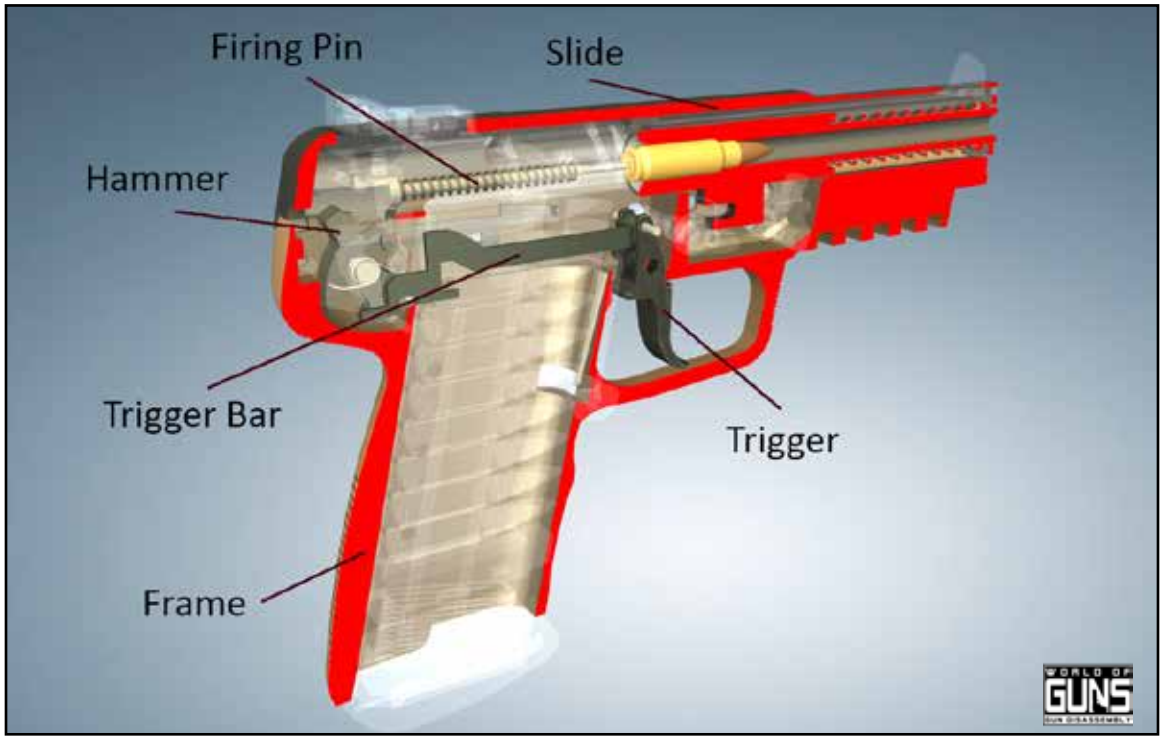

Figure 3: Hidden hammer hammer-fired system.

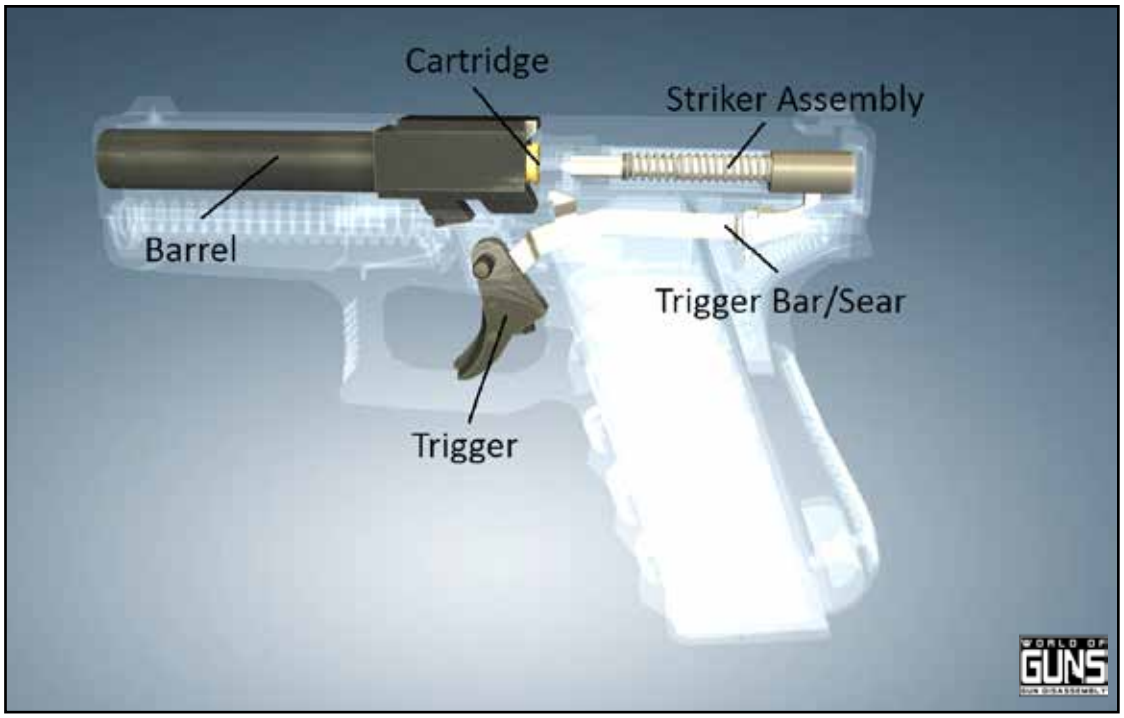

Figure 4: A striker-fired system.

Typically, the fire control group lives in the frame/receiver of the firearm and the striker lives in the bolt/breechblock/slide. Only the trigger pivots on a pin in the frame/receiver. When the trigger releases the striker, it will plunge forward under spring force. The weight and speed of the striker is critical to proper ignition without damage to the primer.

Each system has its own advantages and disadvantages, but both systems are equal in their performance and reliability. The hammer-fired system has the advantage of being able to be manually cocked and de-cocked by the operator. Some hammer-fired, semi-automatic models also feature a "second chance" capability, allowing you to try to fire a cartridge that failed to ignite from the first impact. The hammer-fired system also has the advantage of being more robust and heavy duty.

The striker-fired system has the advantage of being more compact and simple. This is especially important with semi-automatic pistols, where a thin slide and low bore axis are concerned. The system also has the advantage of having a faster lock time. Lock time is the time it takes from the moment the trigger releases the hammer/striker to the point where the firing pin/striker contacts the primer and initiates ignition. Even though this happens within milliseconds, any disruption in the firearm and sights at this time will cause the point of aim and point of impact to deviate. Reducing the lock time will reduce the possibility of deviation in the intended trajectory. By design, the mechanics of the striker-fired system allow it to be much faster than the hammer-fired system, although aftermarket parts can be used to speed up both systems.

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Single- and Double-Action and Single- and Two-Stage Trigger

SINGLE- AND DOUBLE-ACTION TRIGGERS

Depending on the system, the trigger motion itself will perform multiple actions through various stages of travel. Regardless of whether the system is hammer- or striker-fired, the trigger may perform various actions with different stages. First, we will discuss trigger actions.

There are two trigger action types: single- or double-action. Single-action is so named because of the fact that the trigger only performs one action: when the trigger is pressed, it will release the hammer/striker (either directly or through some other mechanical means). This means the hammer/striker must be manually cocked (via hammer or through charging the action) before the trigger will function. When the trigger is pressed, the hammer/striker will move, firing the round. Depending on the action type, the hammer/striker must be manually cocked once more or must be cocked by the action cycling before firing again.

The double-action trigger is named so because of the fact that the trigger can perform two actions: when the trigger is pressed it can both cock and release the hammer/striker (either directly or through some other mechanical means). This means that the hammer/striker does not have to be manually cocked before the trigger will function. The double-action trigger is also capable of functioning in a single-action mode. If the hammer/striker is down (in the de-cocked position) when the trigger is pressed, the movement of the trigger will drive the hammer/striker into the cocked position before releasing it and firing the round. If the hammer/striker is cocked, pressing the trigger will simply release it.

Both trigger action types have their advantages and their disadvantages while performing the same basic action. The single-action trigger system tends to have the benefit of a short, light trigger pull. This is because the hammer/striker

Figure 5: Single-action trigger function.

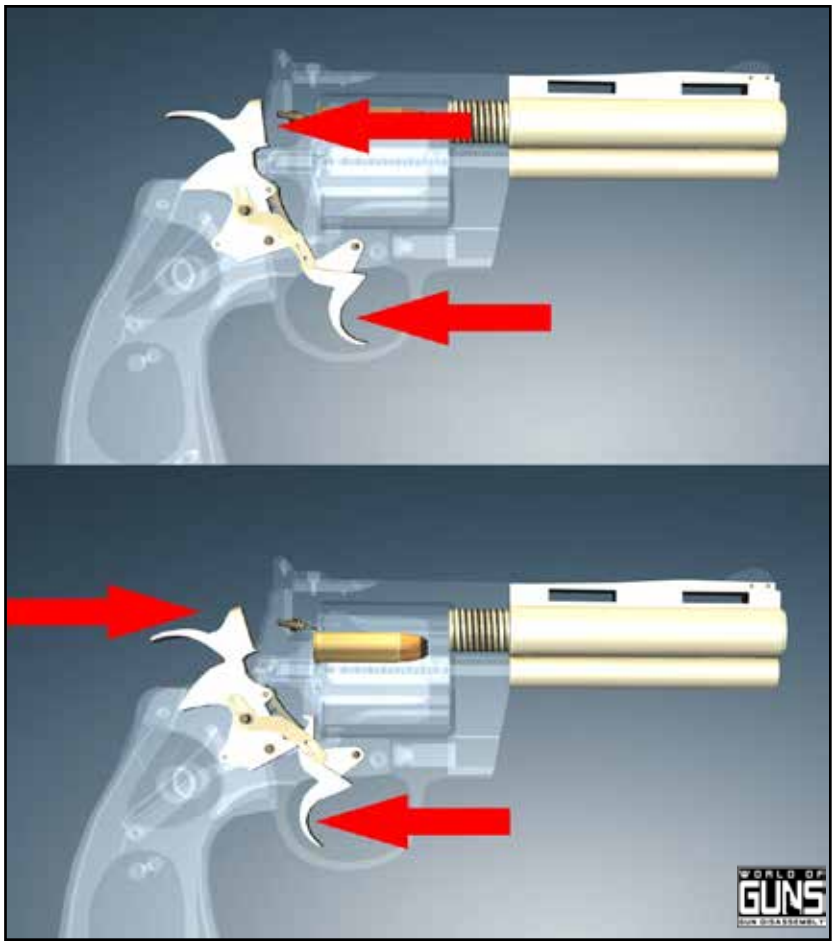

Figure 6: Double-action trigger function.

is already cocked so the trigger only needs to move a small amount before the hammer/striker is released; the system is also much lighter for the same reason. Of the two styles, the single-action system has a higher chance of an accidental discharge because of its pull length and weight.

The double-action trigger system has the benefit of being very safe and more versatile. The pull when the hammer/striker is down tends to be very long and heavy because the movement of the trigger must cock and release the hammer/striker. The double-action system also has the same benefits as the single-action trigger when the hammer/striker is cocked. Another benefit of some double-action trigger systems is the ability to restrike the primer if the first attempt fails. This is especially useful with semi-automatic actions because simply pulling the trigger could resolve what would otherwise be a malfunction. The same benefits that make the system safe are also the same hindrances that make it a bad choice for accuracy. The long, heavy pull allows for greater disruption in the firearm before discharge, diminishing the ability for precision.

SINGLE- AND TWO-STAGE TRIGGERS

Before talking about single- and two-stage triggers we need to discuss some of the terms involved in the feel of the trigger when it is pressed. Understanding how each of the stages of the trigger press operates and feels will help you to diagnose and remedy any issues that may arise with the fire control group. The following terms describe the different stages of the trigger press:

- **Pre-Travel/Take-Up** – Pre-travel or "take-up" is the slight movement of the trigger before reaching the "wall" or trigger engagement. This initial movement allows the trigger to engage the rest of the fire control group to begin the process of releasing the hammer/striker. Often with the take-up, only the trigger and possibly some linkage will move until the system engages the sear surfaces of the trigger/linkage or sear and hammer/striker. This engagement is known as the wall. Beyond the wall, the sear surfaces begin to shear past one another before the hammer/striker is released. The pull weight of the pre-travel is also very light compared to the second stage. With some trigger designs, part of the pre-travel may also involve deactivating some type of trigger safety. Pre-travel is not part of every fire control group design.

- **Creep** – Creep is the feel of the sear surfaces on the trigger/sear and hammer/striker shearing across each other. A certain amount of creep is a necessity for safe function, but an excessive amount of creep can be bad for accuracy and precision: too little creep and the system may fail to engage or reset, causing a misfire. Creep begins at the wall between the first and second stages and ends at the "break." Both the trigger/sear and hammer/striker are sprung in such a way that they force the sear surfaces into each other. Depending on how well the parts were machined and finished, the sear surfaces may be mirror smooth, or rough, drastically affecting the feel of the creep.

- **Break** – Break is the feel of the trigger/sear releasing the hammer/striker. The shape of the edge of both sear surfaces and the hardness of the parts will determine the feel of the break. With other designs the tolerances of the parts involved will also affect the break. The feel of the break may be one of two ways: crisp or soft. A crisp break will feel like a piece of glass breaking — sudden and sharp. A crisp break is from sear surfaces with sharp edges that are very hard. The sear surfaces will clear each other suddenly, creating a break that is a surprise. A soft break will feel like a twig breaking. You will feel the sear surfaces roll off of each other and be able to anticipate the break. A soft break is caused by sear surfaces with round edges or soft material being used for the trigger/sear and hammer/striker. The sear surfaces will reach the edge and roll or slide past each other, making the break feel soft. With some striker-fired, semi-automatic pistol designs, the tolerances between the slide and frame will make the break feel soft or mushy. This soft or squishy feeling comes from the fact that part of the fire control group is in the frame, while the striker is in the slide. Any slop in the frame-to-slide fit will be transmitted to the feel of the break, as the sear drags the striker and slide downward before bottoming out on the rails and the sear continues downward, releasing the striker.

- **Over-Travel** – Over-travel is the feeling of the trigger after the break. Over-travel is a feeling of nothingness. The over-travel stage occurs after the break when the trigger's movement continues until it bottoms out of its stroke. The over-travel stage is often lightly sprung, which allows the trigger motion to accelerate after the break because the trigger is no longer fighting the forces of the hammer/striker. A small amount of over-travel is required for proper function, ensuring the system is allowed to break. Too much over-travel will cause disruption in the firearm when the trigger bottoms out in its travel.

- **Reset** – Reset is when the trigger must be released into its forward position so the fire control group can reengage. Reset occurs with most repeating and semi-automatic firearms to prevent automatic fire. When the round fires and the action cycles, a tab or mechanism disconnects the trigger from the rest of the fire control group as the hammer/striker is cocked. The trigger must be released in order for the mechanism to reconnect and the firearm to be fired again. The distance of the reset may not be as long as the initial pull because the hammer/striker will already be cocked and the trigger will be in a single-action position. A short reset is equal to a short pull and is great for rapid fire shooting because the trigger only needs to travel a short distance to break.

Now that you understand the stages of a trigger pull, we can discuss the differences between a single- and two-stage trigger. As its name implies, a single-stage trigger only has one stage before the break. There is no take-up or pre-travel, but only the wall. When the trigger is pressed, all that is felt is creep before the break. A two-stage trigger is so named because of the fact that the trigger has a pre-travel stage before the break. When the trigger is pressed, there is an initial pre-travel before reaching the wall. When the trigger reaches the wall, slightly more pressure is required to achieve the break.

Both systems have their own advantages and disadvantages and are used in different applications. Various designs use both actions and stages to achieve the perfect pull for their desired results. For example, the AR-15-style firearms utilize single-stage, single-action trigger systems. The design relies on the weight of the pull and the large amount of creep to safely function. When the trigger is pressed, you will feel about 4 – 7 lb. of resistance and between a 1⁄16 in. and 1⁄8 in. of creep before the break. Although the weight is fairly heavy and there is a significant amount of creep, the whole pull is fairly short with a short reset, which allows for fairly fast rapid fire.

Another example would be a 1911-style trigger system. The 1911 uses a two-stage, single-action trigger. The design relies on the first stage to prevent accidental discharge because the actual weight of the break is fairly light. When the trigger is pressed you will feel a very short take-up, with around 1 – 2 lb. of resistance before reaching the wall. An additional 1 – 2 lb. of pressure is required to reach the break. Although the overall weight of the pull is fairly light, the addition of the first stage adds a degree of safety to the system. This allows for a light trigger with a short travel that is safe.

With double-action systems with the hammer/striker down there typically is no pre-travel. Any travel in the system is transferred to cocking the hammer/striker. If the hammer/striker is already cocked, there may be some take-up, as the trigger must move until contacting the hammer/striker. The double-action makes the extra stage redundant; therefore double-action systems hardly ever feature a two-stage operation.

Basic Parts and Assemblies

Regardless of firearm type, action, or operation type, or any other form of categorization, all firearms share the same basic parts and assemblies. These base parts form the foundation that firearms are built around. Each part and assembly serves a specific purpose, while all working together to perform one action. The following are the basic parts of any firearm.

- **Frame/Receiver** – The frame or receiver(s) is the central component of any firearm. Almost every part of any firearm attaches directly to the frame/receiver or to a part attached to the frame/receiver. This includes the barrel, action, fire control group, controls, sights, furniture, and possibly magazine(s).

  Because the frame/receiver is such an important component to any firearm, in the U.S., the frame/receiver is the part of the firearm that is regulated and serialized. The ATF requires the manufacturer's name, city and state, model, and serial number on every frame/receiver manufactured and sold in the U.S. The ATF also requires that a stripped (bare) frame/receiver must be transferred to a person who is 21 and older, who completes a background check in their state of residence.

  The construction of the frame/receiver varies as much as its features. Depending on make and model, material and manufacturing processes will vary greatly. Material selection is typically based on caliber and application. Large caliber firearms with high chamber pressures will require a strong receiver, typically made of steel, stainless steel, steel alloy, or even titanium. Smaller caliber pistol and rimfire cartridges often use aluminum and aluminum alloys for their frame/receivers, but magnesium and brass have also been used. Modern technology has introduced super polymers and composites to the firearm industry, with both being employed with certain makes and models. Polymer or composite frame/receivers often rely on metal (steel, aluminum, brass, etc.) inserts to reinforce certain areas of the frame/receiver.

Figure 7: Various firearm parts.

The manufacturing process will also differ with each make and model of firearm. The manufacturing process for frame/receivers include forging, milled, extruded, cast, stamped, or injection-molded. Forging involves pressing a hot blank into shape with a hydraulic forging press, and 30+ tons of force. Once cooled, the blank is trimmed and machined into its final shape. Milled frames/receivers begin life as solid billet blanks that are machined into their final form.

The extrusion process involves forcing molten material through a specially shaped die (typically "O" shaped), which forms a long, continuous blank when cooled. The blank is then cut to length and machined into its final form. Extruded frame/receivers are typically tubular or square and reserved for bolt-action-style firearms. The injection molding process involves forcing molten material into a specially shaped mold. Once the material cools, the blank is removed from the mold and the molding tabs are removed. Injection-molded frames are often complete once removed from the mold, or require very little machining and finishing. The injection molding process is typically reserved for polymer and composite materials.

The stamping process involves thin metal sheet material that is cut and shaped by a hydraulic press and dies. The press forces the sheet metal into shape between the two dies and then trims any excess material. When the frame/receiver is removed from the press it is typically complete, with little to no machining required. Stamped frame/receivers may also be comprised of multiple stampings that are welded together. The casting process involves pouring molten material into a mold and allowing it to cool. The molds are often made of sand, plaster, or wax and are often destroyed when the frame/receiver is done. Once the material has cooled, the frame/receiver is removed, cleaned up, and trimmed, and finally machined into its final shape.

Figure 8: Various frames/receivers.

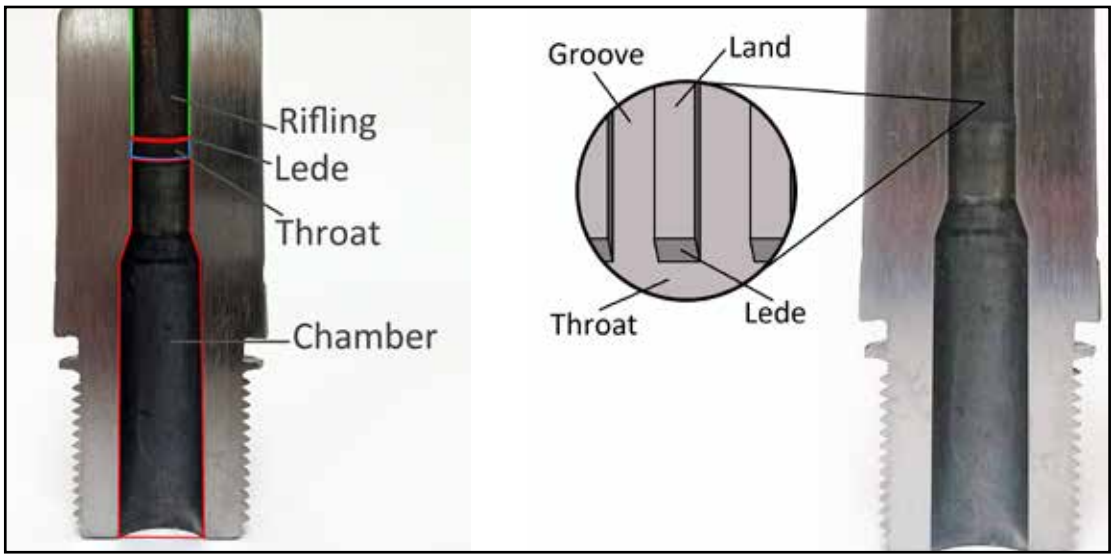

Figure 9: The relationship between the chamber, throat, leade, and rifling.

- **Barrel** – The barrel of any firearm is one of the most critical components, outside of the bolt/breech block/slide. The barrel (and bolt/breech block/slide) must contain all of the pressure and energy from the cartridge discharging, which can be as much as 60,000+ psi. The barrel must also stabilize the bullet as it passes through the bore.

  The barrel consists of a metal tube that may or may not be rifled. Rifling is a series of high and low spots (lands and grooves or hills and valleys) inside the bore of the barrel that extend the length of the bore and are arranged in a helical pattern. As the bullet/projectile is being forced through the bore, the bullet will engage the rifling and begin to rotate. The spin that is imparted stabilizes the projectile in flight. The barrel may also feature an integral chamber (revolvers utilize a chamber that is separate from the barrel). The chamber is shaped like its intended cartridge and is designed to handle most of the strain. Part of the chamber's design will include a "shoulder" of some type that will space the cartridge inside the chamber.

  Just ahead of the chamber is the "throat." The throat is a free space that allows the bullet to pass from the case and into the leade and then the rifling with little resistance. The throat is designed to prevent pressure spikes in the chamber from the bullet's movement being delayed by the rifling. Just ahead of the throat is the leade. The leade is like a ramp at the beginning edge of the rifling. The leade aligns and guides the bullet into the rifling.

  Barrels that do not feature rifling are known as smoothbore. Smoothbore barrels do not impart any spin on the projectile and have no throat or leade. Instead, smoothbore barrels feature a "forcing cone" just ahead of the chamber (revolvers use a similar feature at the mouth of the barrel, just ahead of the cylinder). The forcing cone decreases the diameter of the barrel just ahead of the chamber, compressing the projectiles and creating a tighter grouping. Smoothbore barrels are typically reserved for shotguns and shotshells loaded with birdshot and buckshot.

There are many different options for rifling, but the different styles fall under two basic categories: traditional (Enfield) and polygonal (Metford). Regardless of style, all rifling is designed to accomplish the same task: impart spin on the projectile. Traditional rifling consists of a series of "lands and grooves," which are raised and recessed sections inside the bore. The lands and grooves feature very sharp 90 degree transitions between each other, which leave very defined grooves in the bearing surface of the bullet. Canted land rifling is a modified form of traditional rifling. Canted land rifling still utilizes some of the same 90 degree transitions as traditional rifling, but the land itself "leans" to one side. The lands themselves are slightly canted to one side and some of the edges are beveled. Ratchet rifling is a form of canted land rifling.

Polygonal rifling differs from traditional rifling significantly. All sharp edges are done away with and lands and grooves are replaced with "hills and valleys." The hills and valleys are a series of arcs inside the bore. The transition between the hills and valleys is smooth and leaves little to no deformation in the bullet.

The type and shape are not the only important factors when discussing rifling; "twist rate" can be more important for the stabilization of the projectile than rifling. Twist rate is a relationship between the rifling and the distance it spans while twisting through the barrel. For example, a twist rate of 1 in 7 in. means that the rifling will complete one full revolution inside the bore within 7 in. of barrel length. Various twist rates are used for different calibers to stabilize various projectiles. Typically, the longer the projectile, the faster the rate must be to properly stabilize it (1 in 7 in., 1 in 6 in.). The shorter the projectile, the slower the twist can be (1 in 16 in., 1 in 18 in.). Comparing twist rates and long and short projectiles to footballs and baseballs (respectively) makes understanding twist and stabilization much easier. When a baseball is thrown, it requires little to no spin to properly stabilize in flight. But when a football is thrown, if it is not spinning fairly quickly, it will wobble in flight.

Figure 10: Different types of rifling.

Another critical area of the barrel is the muzzle crown. The shape of the muzzle is critical for the accuracy and precision of any firearm. Because the muzzle is the last part of the firearm to touch the projectile, its concentricity is key. When the bullet leaves the muzzle, the high pressure gasses pushing against it will still act upon it in the open atmosphere. If the muzzle shape is damaged or not concentric, it will direct the gas unevenly around the bullet, forcing it off of its intended course. A concentric muzzle will distribute the exiting gasses evenly around the bullet, causing little to no disruption in trajectory.

There are different shapes of muzzle crown, each with their own benefits, though the concentricity of the crown is more important. The most popular muzzle shapes are flat, round, and 11 degrees. A flat crown is exactly what its name implies: flat. The flat crown is perfectly 90 degrees perpendicular to the bore, with a slight 45 degree bevel at the bore. The round crown is also appropriately named because the muzzle shape is rounded. The 11 degree or "target" crown has gained a lot of popularity as a precision muzzle crown. The 11 degree crown consists of an 11 degree bevel, perpendicular from the bore. This slight bevel is believed to be the best shape for the smoothest transition of the exiting gasses. This ensures the exiting gasses do not disrupt the bullet's intended trajectory.

Because the barrel is an extremely critical component, it is always made of steel, stainless steel, or some other steel alloy. Only steel (and its alloys) can be trusted to withstand the forces experienced when a cartridge is discharged. The heat treatment of the barrel is also critical to its

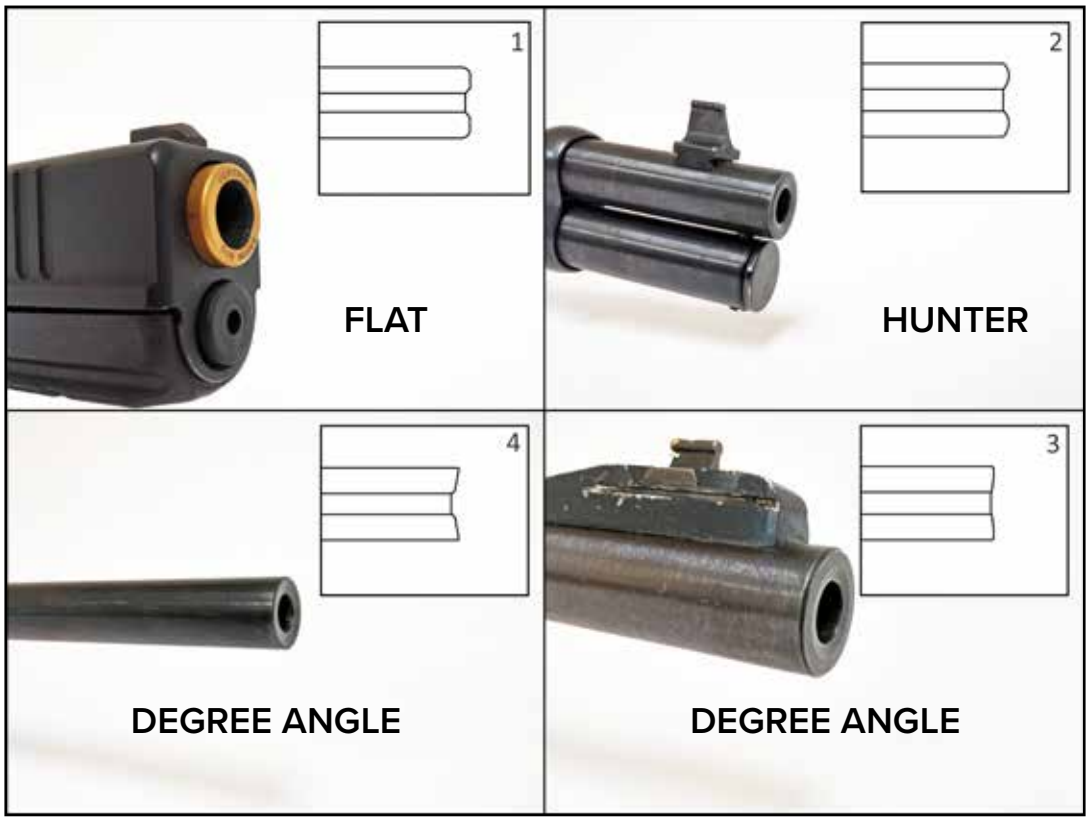

Figure 11: Various muzzle crowns.

performance. The barrel must exhibit a certain amount of "flex" or elastic deformation in order to contain the huge pressures inside. A barrel that is too hard may be brittle and crack or break instead of flex under pressure.

There are basically three manufacturing processes used to complete firearm barrels and form rifling. All three processes begin in the same manner, as a solid rod blank. The blank is then drilled undersized (smaller than the final dimensions), lapped, and polished. This is where the three processes differ. The three basic rifling forming processes are hammer forged, button, and cut. The three processes can be used to form both traditional rifling as well as polygonal rifling with varying numbers of lands and grooves (three, four, five, six lands).

Hammer forging forms the rifling by hammering the drilled barrel blank around a mandrel that features a reverse pattern of the rifling itself. The hammer's impact moves the barrel's material into the mandrel and forces the bore to conform to the rifling on the mandrel. A downside to hammer forging is the introduction of work hardening and uneven stresses that are placed on the material. Hammer barrels must undergo additional tempering processes to remove these introduced stresses. The hammer forging process creates very uniform, smooth rifling and a very hard bore during the forging process.

The button rifling process involves pushing or pulling a carbide "button" through the drilled blank as it rotates. The button features several protrusions around its diameter shaped like a male pattern of the rifling. The size of the protrusions becomes progressively larger along the button's length. The button is used to press or "iron" the shape of the rifling into the blank. The button rifling process workhardens the bore of the barrel and creates very uniform rifling that is very hard. Button rifling produces a higher grade barrel than hammer forging at a price only slightly higher. Button rifling can be performed on most barrel materials.

Cut rifling involves pulling a single-point cutter through a barrel and cutting one shallow rifling groove at a time. Cut

Figure 12: Various firearm barrels.

Figure 13: Various action parts.

rifling produces more uniform, precise rifling, and is used in only the best match grade barrels. After each pass, the barrel is indexed and another groove is cut. Grooves are cut either individually or simultaneously. The process continues until all grooves are cut to depth. The cut rifling process is more involved and time-consuming than any other process, but creates the best rifling possible.

- **Action** – The action is like the engine of a firearm. The action controls a majority of the cycle of operations. As previously discussed, there are many action types and operations and many variants of each. The most common types of action parts are breechblocks, bolts, slides, extractors, ejectors, and various locking or closing mechanisms.

- **Fire Control Group (FCG)** – If the action is the engine of a firearm, the fire control group is the ignition that turns the action on and the throttle that keeps it moving. When the trigger is pressed to the rear of the firearm, it initiates a series of events that lead to ignition of the cartridge. As previously discussed, there are two basic kinds of fire control groups (hammer and linear hammer, commonly known as striker-fired) and several modes of operation (single- and double-action/ single- and two-stage). The most common types of fire control group parts are triggers, hammers/ strikers, sears, firing pins, springs, and various types of linkage.

- **Controls** – If the FCG is like a firearm's ignition, the controls are like the brakes, clutch, and gear shift knob. The controls are used to select the firing mode (Safe, Fire, Auto, Burst), remove and replace a magazine, load and lock the breech open, or open the action completely. The controls are used to complete functions other than firing. The most common controls are manual safeties/ selectors (there may be other automated, redundant safeties that are activated by other parts of the action), bolt/charging handles, bolts/slides, magazine catches/ releases, and takedown levers.

- The manual safety/selector is used to activate various modes of operation, depending on the specific model. The basic types of operation the safety/selector permits

are Safe, Fire, Burst, or Auto. When the safety/selector is set in the Safe position, the FCG becomes inoperable. Depending on design, the safety/selector will block the trigger/hammer/sear's movement or will disconnect the trigger from the rest of the FCG. A tab or lug on the safety/selector may engage one or more of the trigger, hammer, or sear directly, completely constraining its movement, or will engage some type of connector or linkage that will detach the trigger from the other components. When the trigger is pressed, depending on design, it will feel solid and not move or it will feel light and move freely. The difference between the safety and the selector lies in the function of the firearm. Manual and semi-automatics typically employ a safety that has two modes: Safe and Fire. Automatic and burst fire guns will use a selector that will allow from two to four modes, depending on design: Safe, Semi (-automatic), Auto (-matic) and/or Burst.

There are two basic safety/selector designs: button and lever. There are variations of the button design that are based on the way it is manipulated. Some buttons are pushed, like with crossbolt safeties found behind the trigger on the trigger guard of some designs. Other buttons must slide back and forth between modes. There are also variations of the lever design. Some levers rotate, engaging different modes as they turn. A fairly new style of lever safety is being employed with the trigger safety. The trigger safety is a true lever design with one leg of the lever protruding from the trigger's face and the other leg in the path of the frame. When the operator places their finger on the trigger, depressing the safety, the opposite leg moves out of line of the frame and allows the trigger to move backward. Safeties/selectors are made from various materials, including steel, aluminum, and polymer.

Proper function and care of safeties/selectors is critical to any firearm's function. Safeties/selectors that become damaged or broken, or even extremely dirty, can become very dangerous. A failure in the safety/selector can lead to an accidental

Figure 14: Various fire control group parts.

Figure 15: Various types of safeties and selectors.

discharge that can lead to injury or worse. Take the time to clean and perform maintenance on the safety/selector when cleaning your firearm.

The bolt/charging handle is used to manipulate the action, often completing many of the cycles of operation. The bolt/charging handle is found with both manual and semi/automatic actions in both rifles and shotguns. Typically, repeating pistols do not use bolt/charging handles (with semi-automatic pistols, the slide itself is manipulated like the bolt/charging handle). With an empty chamber, when the bolt/charging handle is pulled to the rear of the firearm, the action is opened and often the hammer/striker is cocked. Depending on action type, the bolt handle may need to be pushed forward, feeding and closing the breech, or it may be driven forward automatically by an action/recoil spring (the same is true of the slide for a semi-automatic pistol). The bolt/charging handle can also be used to clear malfunctions, if the need arises. The bolt/charging handle may be integral with the bolt/carrier or a separate assembly. With the pump/slide style action, the forend acts as the charging handle and is manipulated manually, back and forth.

The bolt/slide catch serves to hold the bolt/slide in the open position when the magazine is empty. A small tab or protrusion on the magazine's follower engages the bolt/slide catch when the magazine is empty and the follower has bottomed out against the top of the magazine body. The tab or protrusion forces the bolt/slide catch upward into the path of the bolt or slide. As the action/recoil spring drives the bolt/slide forward, it will be restrained by the catch. A tab or lever on the exterior of the catch can be depressed, moving the catch out of line of the bolt/slide and allowing it to travel forward freely. The catch can be manually operated, allowing the user to clear and lock the action open and clear malfunctions. The bolt/slide

Figure 16: Various bolt/charging handle/forend assemblies.

catch is typically made from steel so that it can withstand the impact from the steel bolt or slide.

The magazine catch serves to trap the magazine in the magazine well, in the proper position for feeding. A small lug or protrusion on the catch corresponds to a recess or slot in the magazine body. The catch itself is spring-loaded. When the magazine is inserted into the magazine well, the body of the magazine will force the catch outward until the recess/slot aligns with the lug/tab. The spring will force the lug/tab into the recess/slot and lock the magazine in place. Once the magazine is empty, the operator can depress the magazine catch and remove the magazine. The lug/tab on the catch will clear the recess/slot in the magazine's body and allow the magazine to move freely.

The takedown lever/pin(s)/button serves to open and disassemble the firearm. Manipulating the takedown lever/pin will allow the operator to disassemble the firearm for maintenance or cleaning. The lever or pins operate in various ways from sliding or rotating, to simply being removed. Typically, the takedown lever/pin will hold two separate major assemblies together that form a functioning firearm. To reassemble the firearm, typically, all you need to do is assemble the major assemblies and return the takedown lever/pin(s)/button to its original position. With some semi-automatic pistols, the takedown lever doubles as a slide catch.

Figure 17: Various bolt/slide catches.

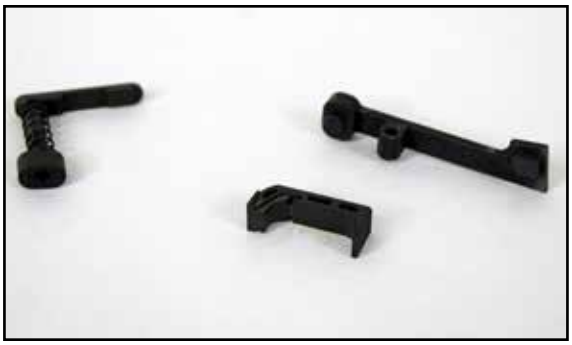

Figure 18: Various magazine catches.

- **Sights** – The sights of the firearm provide a reference point of where the firearm is pointing and an approximation of where the projectile will impact. Two individual sights are aligned to provide a point of aim for the firearm. One sight is near the front (muzzle) of the firearm and the other is farther back, near or on the receiver. There are various types of sighting systems that are used by almost every make and model of firearms. These types of sights are often referred to as "iron sights."

  There are three basic sight setups and many variations of each. The three basic sight types are aperture and post, notch and post, and post only. The biggest difference between the sight setups is the rear sight (or lack thereof); all three styles share the same basic front post design. Pistols will typically use the notch type, while rifles may use either the aperture or notch and shotguns may use aperture or post only.

  Aperture sights are so named because of the use of an aperture assembly for the rear sight. An aperture is a small hole in the rear sight used to view the front sight, similar to the aperture that allows light to enter a camera and create a picture. The aperture itself acts as a collimator, a device that aligns light rays and provides a sharp image. When the sights are properly aligned, the tip of the front post must be perfectly centered in the aperture's window. The aperture itself may vary in size for use at different distances or under different conditions. A larger aperture will allow more light to pass through, creating a larger, brighter sight picture with a larger field of view, but will also allow a greater chance of misalignment because of the larger aperture. A smaller aperture will not allow as much light to pass through and will not allow as large of a sight picture, but will provide a greater chance of accuracy and precision because the smaller aperture does not allow for as much misalignment. Large apertures are typically used for close-to-mid range distances and low light conditions, while smaller

Figure 19: Various takedown levers, pins, and buttons.

Figure 20: Aperture sights.

apertures are typically used for precision shooting. Aperture sights are also known as "peep" and "ghost ring" sights.

Notch sights are so named because of the use of a notch in the rear sight. The notch is just a simple cutout in the rear sight, which provides clearance to view and align the front sight. When the sights are properly aligned, the front post must be centered in the notch with the tops of the post and notch perfectly level. The notch and post will vary in width, with a thicker post and wide notch for quick acquisition and a thinner post and narrower notch for precision shooting. A larger notch will allow more light to pass through, creating a larger, brighter sight picture with a larger field of view, but will also allow a greater chance of misalignment because of the larger notch. A smaller notch will not allow as much light to pass through and will not allow as large of a sight picture, but will provide a greater chance of accuracy and precision because the smaller notch does not allow for as much misalignment.

Post sights are so named because of the use of only a front post sight. Post only sights are also known as "bead" sights. There is no rear sight and the majority of the sight alignment comes from the barrel and receiver. When the bead is properly aligned it is barely visible above the plane of the barrel/receiver and is centered on the target. The bead sight system provides an approximation of impact based on various birdshot and buckshot loads. The bead is typically a small round brass or steel ball that is screwed directly to the barrel. The bead sight system is used primarily with shotguns. The accuracy of the bead sight system can be enhanced with the inclusion of a barrel rib or middle bead. The rib and mid bead provide a second point of reference of where the firearm is pointing.

There are also many different materials used to enhance the visibility/usability of various sight systems. Basic enamel paint is typically the most common sight enhancement, with various color dots

Figure 21: Post and notch sight.

Figure 22: Bead sight.

being painted on the front on rear sights. Phosphorescent paint is also used to create sights that glow in the dark after being charged by an outside light source like a flash light or the sun. Depending on the specific sights, the paint may glow for several minutes to several hours. Various colors of fiber optic rods have been used as inserts for both front and rear sights and provide a very bright colored dot during the day and in bright environments. In low light conditions, the fiber optic does not shine at all and only a dull colored dot is visible. Tritium vials are also used to make sights visible in complete darkness with no external charge. Tritium is a radioactive gas that, when combined with phosphorous powder, will create light. Typical colors include green, yellow, and orange.

- **Furniture** – Furniture provides a place on the firearm for the operator to grip, steady, and control it. The term "furniture" is a generic term for a part, parts, or assemblies that the operator grasps or handles. These parts include grips, buttstocks, and forends/handguards. The furniture a firearm employs depends on the type of firearm.

  Pistols will typically only employ grips because the use of buttstocks would change its classification, while both rifles and shotguns can use grips and buttstocks. The grip is located near the trigger and is held by the shooting hand. The grip is also typically placed in an area where some or most of the controls can be

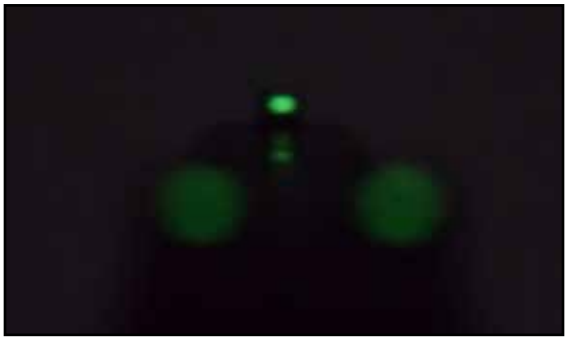

Figure 23: Sight enhancement.

manipulated by the shooting hand. The grip can vary from a single piece to grip panels that attach to the grip of the frame as well as grip inserts to change the feel, shape, and size of the grip. The grip will typically feature some type of texture such as serrations or checkering. Materials will also vary from various woods, rubber, and plastics to composites and various metals. The grip(s) may also feature some type of integral finger groove or thumb rest.

The buttstock is used to steady either a rifle or a shotgun against the operator's shoulder and to help transfer recoil forces over a larger area. The buttstock attaches to the rear of the rifle/shotgun and extends back from 11 in. to 14 in., depending on model. There are several pieces (integral) to the buttstock that all serve a different function. At the rear of the buttstock is the heel (top) and toe (bottom), which provide the contact surface for the stock and shoulder. The angle, shape, and material used in this area are critical to the comfort of the operator while shooting. On the top of the buttstock is the comb. The comb provides a place for the operator to rest their cheek while looking through the sights. The placement and size of the comb are critical to ensuring comfort and proper sight alignment. The buttstock itself may be made from various materials, including metal, polymer, rubber, composite, and wood. Some models may feature stocks that are adjustable for both length and comb height. Other models may feature buttstocks that fold (either side, over, or under the receiver) and collapse. Some models of rifles utilize stocks that feature integral grips, buttstocks, and forends.

The forend/handguard is used on rifles and shotguns to support the front of the firearm and protect the hand from a potentially hot barrel. The forend is located just ahead of the receiver and may partially or fully envelope the barrel. The forend is gripped by the support hand

Figure 24: Various types of grips.

Figure 25: Various types of stocks.

while the shooting hand is on the grip and the buttstock is contacting the shoulder. The forend may or may not make full contact with the barrel. Some forends/handguards allow the barrel to "float" inside. Like the grip(s), the forend may also be textured or shaped to provide a better grip for the operator. The handguard may be made from various materials such as metal, wood, polymer, or composite. The forend may also feature some type of provision for mounting accessories like bipods, lights, foregrips, lasers, bayonets, or other items.

Figure 26: Various types of forends/handguards.

Chapter 7: Magazines and Other Feeding Devices

Magazines and Other Feeding Devices

A magazine is a device used to feed multiple cartridges into the breech of a repeating firearm. Magazines can vary as much as firearm types and actions. Typically, a magazine is proprietary to its specific firearm model, but each model may be able to accept multiple sizes and styles.

MAGAZINE TYPES

Magazines can be classified by a few characteristics. The first major classification divides magazine types into two categories: fixed (internal) and detachable. The second classification divides magazine types by the way the cartridges are arranged, while the third classification divides types by the way the cartridge is fed.

Magazines will also differ in material types. Magazines are typically an assembly, composed of multiple pieces that can also be made of different materials. A magazine is typically made up of a body, follower, and spring. The body and follower are typically made of metal, polymer, or composite while the spring is always made of some type of spring steel. The body (and possibly follower) will have a few specific features.

When the magazine is loaded, the rounds will push against the follower and cause the spring to compress. When cartridges are fed by the action, the spring forces the follower to push another cartridge into the path of the feeding action. Once the magazine is empty, some designs will lock the action open, allowing the operator to visualize the empty breech and reload or load a new magazine.

INTERNAL BOX MAGAZINE

The internal box magazine or blind box magazine is a feeding device that lives under the action of some firearms and is (mostly) fixed in its

Figure 1: Various types of detachable magazines.

position. The design gets the name "blind box" from the fact that the magazine is not visible from the exterior of the firearm. The magazine is only accessible once the action has been locked open. Internal box magazines are fixed in their capacity (without modification) and typically hold from 3 to 5 rounds.

While most internal box magazines must be loaded manually one at a time, some designs employ clips or stripper clips. The clip or stripper clip holds multiple rounds (usually 5 – 10) in a thin metal strip or block (en bloc) and fits into a recess in the magazine. The rounds are stripped from the clip and loaded into the magazine, making loading much faster. The clip is removed and the firearm can now be chambered and fired.

FIXED TUBULAR MAGAZINE

The fixed tubular magazine gets its name from the shape of the magazine body. The tubular magazine in its most basic form is just a tube with one end capped off. The tube is fixed (either screwed, brazed, or pressed and pinned) to the receiver with the open end facing the breech. Inside of the tube is a round follower and coil spring. There is another type of tubular magazine that is not quite fixed, but not completely removable. It is basically a tubular magazine inside of a tube that is fixed to the receiver. Depending on model and design, the cartridges may either be loaded from an opening or window in the receiver or through a window in the front of the magazine tube. The cartridges are arranged in line from tip to base, with the tip (bullet) facing the muzzle. Inside of the receiver, near the mouth of the magazine tube, there will be two assemblies that control the feeding of the cartridges from the magazine. These parts are known as "stops" and "interrupters." The stop prevents cartridges from being forced into the breech prematurely. The interrupter prevents the next cartridge from being released from the tube once the stop has been tripped, releasing the first round. Both the stop and the interrupter are activated by the movement of the action, which also controls their timing. The fixed tubular magazine is used with both manual and semi-automatic actions in both rifles and shotguns. The major advantages of the tubular magazine design are its simplicity and fairly high capacity (6 – 20 rounds, depending on caliber). One major drawback of the design is that it can be extremely dangerous, depending on the type of ammunition used. Using spitzer (spire or pointed) bullets can lead to an accidental discharge inside of the magazine tube that will create a domino effect of accidental discharges down the

Figure 2: Internal box or blind magazine.

Figure 3: Tubular magazine.

Figure 4: Various detachable magazines.

entire length of the magazine. This occurs when spitzer bullets contact the primer of the round in front of it during recoil and the round ignites, driving the bullet into the round in front of it and so on. This catastrophic failure is extremely dangerous and will cause injury or worse. This is why tubular magazines are only recommended for blunt or round nose ammunition. But they are very useful with rimmed ammunition to avoid rim lock.

DETACHABLE MAGAZINE

The detachable magazine is a feeding device that is removable from the firearm and can be replaced by another magazine of the same design. Unlike the fixed magazine, the detachable magazine can be removed from the firearm, loaded, and replaced. The detachable magazine is locked in place in the firearm by the magazine catch/release and released by the same. The detachable magazine can range in capacity from 3 to 150+ rounds, depending on caliber and design.

The detachable magazine is typically composed of a body, follower, spring, and base plate. The body is used to contain the follower, spring, and cartridges, while the base plate closes the body and traps the other components. The body will feature feed lips, which support and align the rounds in preparation for feeding. The body will also feature a recess, cutout, or tab that locks the magazine into the firearm via the magazine catch/release. The follow may feature some type of tab or protrusion used to activate the bolt/slide catch when the magazine is empty.

While most detachable magazines must be loaded manually one at a time, some designs employ clips or stripper clips. The clip or stripper clip holds multiple rounds (usually 5 – 10) in a thin metal strip and fits into a recess in the magazine or by the addition of an adapter to the magazine to accept the clips. The rounds are stripped from the clip and loaded into the magazine, making loading much faster. The clip is removed and the magazine can be inserted into the firearm and made ready to fire.

OTHER DETATCHABLE MAGAZINE DESIGNS

The detachable magazine is not restricted to one specific design or style — there are as many magazine styles and types as there are repeating firearms. The magazines will differ in shape, size, and cartridge arrangement and feeding. The most common detachable magazine designs are box, drum, helical, horizontal, rotary, and tubular.

The detachable box magazine gets its name from the fact that the magazine is shaped like a box. The box shape can be squarer or more elongated like a rectangular box. Instead of being six-sided like a true box design, the magazine is five-sided, with the top of the magazine being open for loading and feeding cartridges. With some calibers, the box design may curve to accommodate the taper of certain cartridges. The cartridges inside the box magazine are stacked in column(s) vertically and the magazine body is typically inserted into the bottom of the firearm; but with some designs it may be inserted in the side or top of the firearm. Depending on design, the box magazine may come in capacities from 2 to 3 to 100+ rounds. The main advantage of the box design is its simplicity. The design is easy to manufacture and is very reliable. The biggest downside to the box design is that to increase the capacity, the magazine must grow in length (its dimensions are fixed width by the magazine well).

The drum magazine is named so because of its body's resemblance to a drum. The main portion of the body is round in shape, but there is also a box-shaped protrusion on the top of the magazine. The top portion fits into the magazine well of the firearm, while the round body hangs below. The cartridges inside the round part of the body are arranged in a circle that leads to the boxed portion of the magazine where the cartridges form a column. The drum magazine's operating mechanism is drastically different than the box magazine. While the box magazine uses a spring that forces a follower to push against the rounds vertically, the drum magazine uses a spiral (torsion) spring that is wound up when the magazine is loaded. The drum magazine still uses a follower, but the design also incorporates a sprocket that is used to separate and align the rounds inside of the

Figure 5: Various detachable box magazines.

Figure 6: Drum magazine.

magazine's body. As the magazine is loaded, the rounds will push down against the follower and cause the spiral spring to begin to wind. Once the follower and cartridges have cleared the box potion of the magazine and enter the drum, the sprocket will begin to load rounds between its teeth as it rotates with the spiral spring. Some drum designs feature an external "crank" that is used to assist the magazine in winding the sprocket and spring. There is also a variant of the drum magazine called the double drum or "saddle" magazine. The double drum design combines two separate drum bodies into one body. Both sides of the double drum function like a conventional drum with cartridges from each side converging into a single or double stack in the vertical portion of the magazine's body. The drum magazine is typically used in the same applications as the box magazine and is inserted into the firearm in the same ways. The main advantage of the drum design is that it can hold up to 150+ rounds (depending on caliber) in a very compact package. The biggest disadvantages of the drum design are that they are often quite heavy and complex.

The helical magazine gets its name from the way the cartridges are aligned within the magazine. The arrangement of the cartridges inside the helical magazine's body forms a helix. The body of the magazine itself is tubular, but there are helical-shaped fins or channels inside of the magazine's body, which align and organize the cartridges. The helical magazine works similarly to the drum magazine and even uses a spiral spring that is wound when rounds are loaded. The helical magazine differs from the drum magazine in the fact that the body can hold many more rows or ammunition than the single row of the drum. The helical magazine also relies on a separator instead of a sprocket to organize the rounds inside of the body. As the helical magazine is loaded, the rounds push against the follower and drive it around the inside of the body (following the channels/fins) and

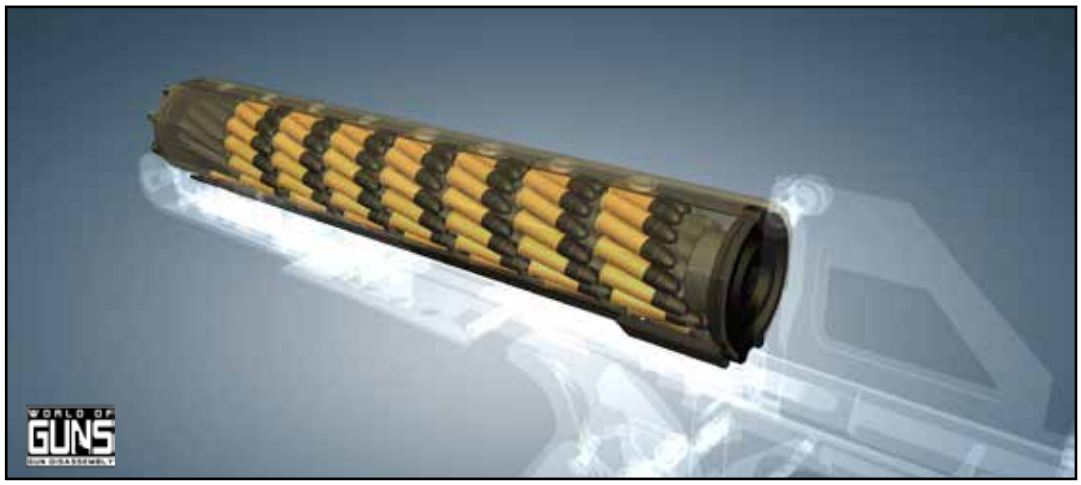

Figure 7: A helical magazine.

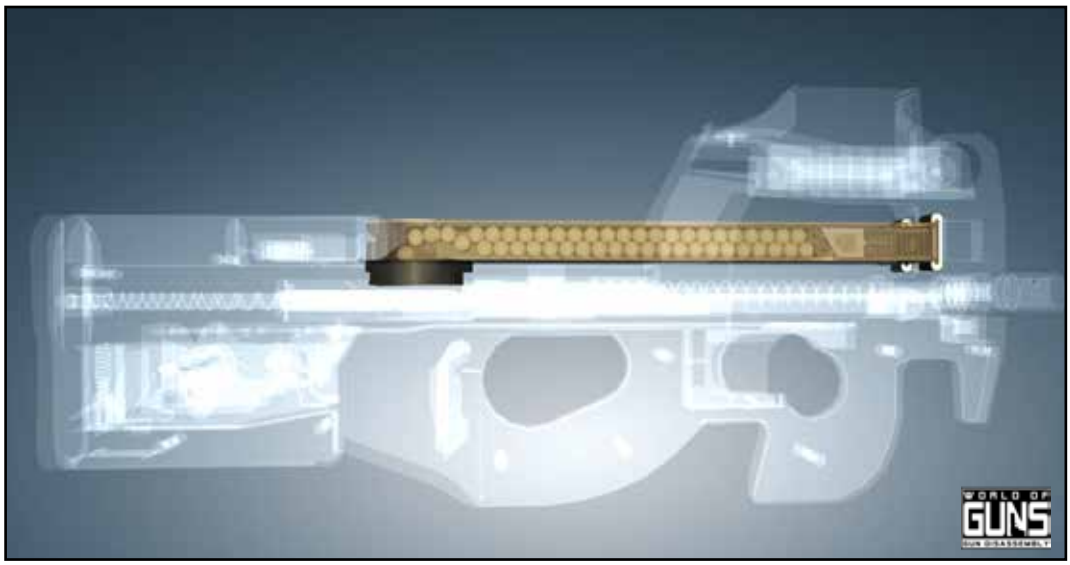

Figure 8: A horizontal magazine.

separator. As the magazine is loaded, the rounds will continue to push the follower back and around the separator and at the same time wind the spiral spring. Typically, the helical magazine is loaded from the top rear of the magazine and the rounds move forward as they are loaded. A variant of the helical design, the "pan" magazine utilizes the helical arrangement, but unlike the standard helical magazine that arranges rounds that point toward the muzzle of the firearm, the pan arranges rounds around an axis that is perpendicular to the bore's axis. The rounds inside the pan magazine lie flat and stack vertically as the magazine is loaded. The advantage of the helical magazine design is its large capacity, often 100+ rounds, depending on caliber. Like the drum design, the biggest disadvantages of the helical design are that they are often quite heavy and complex. A helical magazine design is used by the Calico M960 semi-automatic carbine.

Like the helical magazine, the horizontal magazine gets its name from the way the cartridges are arranged, instead of the shape of the body. The horizontal magazine is actually very similar to the box magazine. The horizontal magazine is basically a box magazine that is laid down on its side and feeds from the bottom. The horizontal magazine's body is even a six-sided horizontal box with a small area near the bottom front for feeding. Typically, the magazine will lock onto the top of the firearm lengthwise (parallel to the barrel), while the cartridges are arranged perpendicular to the bore's axis (horizontally). The rounds are loaded from the rear of the magazine and the rounds move forward as they are loaded. A spring and follower push the rounds backward into a specialized "spiral" feed ramp that turns the round 90 degrees in preparation for feeding. The horizontal magazine can be found in capacities from 10 to 50+. The biggest advantage of the horizontal magazine is the fact that the magazine body lays flush against the top of the firearm and provides a very streamlined profile. A second advantage to this design is that it allows for either a bottom or front ejection system, which makes the firearm easily usable by either left- or right-handed shooters. The biggest drawback would be that the design of the feed ramp adds an extra degree of complexity to a very simple design. A horizontal magazine design is employed by the FN P90 and PS90 semi-automatic bullpup rifle.

The rotary or spool magazine gets its name from the mechanism that arranges and aligns the cartridges. The rotary magazine relies on a part called the "rotor" to hold and separate the rounds inside the magazine's body. The rotor is similar to both the sprocket from the drum

Figure 9: Rotary magazine.

magazine and the separator from the helical magazine. The body itself is typically box-shaped, being squarer than a traditional box magazine. The rotor rotates around a pin that runs through the center of the body parallel to the barrel. The rotor doubles as the follower and is powered by a torsion spring. The rotor features channels along its perimeter that separate the rounds inside the body. When the magazine is loaded, the first round is pushed under the feed lips into the first channel of the rotor. As the next rounds are loaded, the rotor will rotate, exposing empty channels for the new rounds. The rotary box magazine is limited in its capacity, typically featuring between 3 and 10 rounds, depending on caliber. The biggest advantage of the rotary magazine is its compact size and ability to fit flush within the firearm's profile. The biggest disadvantage is its limited capacity.

The detachable tubular magazine functions exactly like the fixed tubular magazine, but can be removed and replaced with a loaded magazine. The detachable tubular magazine differs from the fixed tubular magazine in that the tube itself can be removed from the firearm by simply manipulating the magazine release. The detachable tubular magazine will typically feature its own cartridge stop and possibly interrupter. When the tubular magazine is attached to the firearm, the action will trip the stop and interrupter the same as the fixed tube. A variant of the detachable tubular magazine is used with the SRM Arms 1216 semi-automatic shotgun. The SRM's magazine features four integral tubes that hold 4 rounds each, for a total of 16 rounds capacity. The magazine rotates similarly to a revolver's cylinder automatically after each tube is empty.

SINGLE, DOUBLE, AND QUADRUPLE STACK

Figure 10: A detachable tubular magazine.

The second classifying feature of a magazine is based on the way the cartridges are aligned or "stacked" inside the body of the magazine. The rounds may be arranged in stacks or columns from one to four. When multiple columns of cartridges are staged side-by-side, the rounds will often form staggered columns. A single column arrangement is known as a single stack, while two staggered columns is a double stack and four columns is a quadruple stack or "casket."

A single stack magazine will feature a single row of vertically stacked cartridges. The single stack design is most commonly employed with fixed and detachable box magazines used with pistols, rifles, and magazine-fed shotguns. The single stack magazine often has a very low capacity (depending on caliber) with magazines that feature from 3 to 10+ for larger calibers and up to 30+ with smaller .22 caliber cartridges. The single stack design really shines with semi-automatic pistols, where its thin profile allows for a grip that is also fairly thin. This allows for many more different hand sizes that can comfortably grip the pistol. The single stack design is also very popular with firearms that employ "rimmed" or semi-rimmed cartridges. By stacking rimmed cartridges in a single column, you lessen the chances of a condition known as "rim lock," where the rim of the top cartridge jumps behind the rim of the bottom cartridge. When the round is being fed, it will seize because the rim is pulling the bottom cartridge forward into the magazine's body. Another benefit to the single stack design is that its body can still be configured to work with double stack applications where capacities are limited. The biggest downside to the single stack design is its limited capacity with larger capacity units being ridiculously long without much added benefit.

The double stack magazine will feature two rows of staggered, vertically stacked cartridges. Like the single stack design, the double stack design is employed with fixed and detachable box magazines, as well as drum, helical, and horizontal magazines. The double stack magazine design features very high capacities with magazines that feature from 10 to 40+ rounds in a package that is slightly wider than a single stack magazine. The single stack design is employed by both manual and semi-automatic

Figure 11: Various detachable box magazines.

Figure 12: Various double stack magazine designs.

pistols, rifles, and shotguns with both fixed and detachable magazines. The double stack design is primarily used with rimless and rebated rim cartridges to avoid rim lock. By stacking the cartridges in two staggered columns, you can increase the capacity of the magazine by up to 70+ percent, going from 10 to 17+ rounds in a package that is slightly larger than a single stack magazine. The major advantage to the double stack design is its increased capacity. The major disadvantages of the double stack design are its width, which makes the grip of the handgun wider, and the fact that the second staggered column adds another degree of complexity to the magazine, making it less reliable than the single stack design.

The quadruple stack, or casket, magazine is a very unique design. The casket design is basically three double cartridge stacks inside of a single box-like body. The top of the magazine that fits inside the magazine well of the firearm is shaped like a traditional double stack box magazine, but the bottom (half) of the magazine flares outward and is nearly double the width. The two columns from the upper portion of the magazine are split near the middle of the body and formed into two double stack columns that sit side-by-side. The casket magazine features capacities from 60 to 100+ rounds in a package that may only be slightly wider and longer than a double stack magazine. The casket design may be one of the most complex box magazine

Figure 13: A casket-style magazine.

Figure 14: Various single-feed magazines.

designs, which can be attributed to its additional follower(s), springs, and divider. Like the double stack magazine, the casket design is strictly reserved for rimless and rebated rim cartridges. The major advantage to the casket design is its great capacity. The major drawback is the complexity of the design and that the increased amount of moving parts can cause more reliability issues than a double or single stack design.

SINGLE- OR DOUBLE-FEED

The third classifying feature of a magazine is based on how the cartridges feed from the magazine. There are two ways (based on design) for a cartridge to be fed: single and double. Single-feed magazines will feature a feed lip design that relies on both lips to hold and align the top cartridge in preparation for feeding. Both feed lips make contact with the cartridge until it is stripped by the bolt/slide from the center of the magazine. The next round is pushed up into the exact same position with both lips making contact with the case. The single-feed design is employed by all single stack box magazines, some double stack magazines, and by many other magazine types including drum, helical, horizontal, and all rotary and tubular magazines.

Double-feed magazines will feature a feed lip design that relies on one lip to hold the top cartridge. When the cartridge is stripped by the bolt/slide, the next cartridge rises up into the opposite lip. As the rounds are continuously fed, they will alternate between the two sides. The double-feed design is employed by double stack box and some drum magazine designs. The double-feed design creates a simpler double stack magazine, but makes the design of the firearm more complex. The firearm requires a bolt/slide design that can strip rounds from

Figure 15: Various double-feed magazines.

Figure 16: Detachable cylinder action.

both sides of the magazine, and a feed ramp(s) that can handle cartridges from various angles.

DETACHABLE CYLINDER

The detachable cylinder firearm functions similarly to a double-action revolver, but utilizes detachable cylinders in the same way a magazine is utilized. The cylinder is almost identical to the revolver's cylinder with individual chambers (five to six), locking notches, and a ratchet that is used to rotate it. The cylinder differs in the way that it is attached to the firearm. While traditional revolver cylinders live and rotate on a shaft attached to the revolver, the detachable cylinder uses short round splines to attach and rotate in the firearm. When the cylinder is attached, the chambers will index, align, and lock when the trigger is pressed. Every time the trigger is pressed, the cylinder will rotate and align a fresh cartridge. When all of the rounds have been fired, the cylinder release is manipulated and the empty cylinder is removed. A new cylinder with fresh rounds can now be inserted into the firearm. Although there have been some revolvers that have utilized detachable cylinders, the design has never been as popular as it is with the Six12™ shotgun. The Six12 is a 12-gauge, bullpup configuration that utilizes a six-round detachable cylinder.

BELT-FED

A "belt" is a feeding device that differs from other devices like magazines and cylinders. While magazines and cylinders are limited in their capacity, the capacity of a belt could theoretically be limitless. The belt holds cartridges evenly spaced along its length, arranged parallel to the bore. Provisions on the belt and a mechanism on the firearm will index and move the cartridges and belt. Belts are typically reserved for automatic firearms that can quickly utilize the huge capacity available. Belts are loaded onto a tray or into a port on the side of the firearm. Typically, the first one to three rounds must be manually indexed in the action before the firearm can automatically index. Once the first round is fired,

Figure 17 : Disintegrating metal link belt.

the action moves the belt so that a fresh round moves in line with the chamber. As the firearm continues to fire, the belt will continuously feed through the action.

There are two basic types of belts: cloth/canvas and disintegrating. The first belt-fed designs relied on cloth or canvas belts that featured woven or sewn-in evenly spaced pockets used to hold cartridges. Cloth belts were somewhat limited in their capacities by the length of the belt manufactured, typically 50 – 300. The cloth and canvas material was quickly replaced with disintegrating metal links when it was discovered the material would cause malfunctions when exposed to oil and dirt and debris.

The disintegrating metal link design is similar to a chain, with the links acting as links and the cartridges acting as the pins. When the belt is assembled, one cartridge will connect two separate links. As cartridges and links are added, the belt will grow in length. Because of the "chain" design, the belt can be made into any capacity conceivable (500 – ?). When the belt is being cycled through the action, the bolt will strip the cartridge from the belt and the end link will drop off. As the action continues to cycle and rounds are being stripped, links will continue to drop out of the breech. The metal link has proven itself to be extremely reliable and has found use in firearms like the FN M249 Squad Automatic Weapon (SAW). The flaw of the belt design is that if a cartridge becomes misaligned in the links, the system will bind up.

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